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FRONTISPIECE

Middle Section of Powerline Beaver Pond

THE UNIVERSITY OF ALBERTA

EFFECTS ON FISHES OF CHANGES WITHIN THE KANANASKIS RIVER SYSTEM

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

DEPARTMENT OF ZOOLOGY

by

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ABSTRACT

Fishes in the Kananaskis River system were studied in 1961 to determine the causes for changes in abundance and distribution noted since 1947. These changes have occurred in conjunction with fish introductions and hydro-electric development. Data from surveys since 1936 indicate the probable chronology of events. This study has given some explanations for changes in the fish populations and suggests that the Kananaskis reservoirs are still capable of supporting a good game fish population if proper management techniques are employed.

Competition from *Catostomus catostomus*, *C. commersoni*, and *Salmo trutta*, cooling of the Kananaskis River due to reservoir construction, and lack of proper management of the fisheries have been the chief causes of the decrease in *Salvelinus malma*, *S. fontinalis*, *Salmo clarki*, and *S. gairdneri*. After their introduction by man, *Catostomus catostomus*, *C. commersoni*, *Hybopsis plumbea*, and *Rhinichthys cataractae* greatly increased in abundance. Reasons for subsequent change in numbers of *C. catostomus* remain unknown. Little change has occurred since 1936 in the abundance of *Prosopium williamsoni*, *Rhinichthys cataractae*, and *Eucalia inconstans*. Changes in the physico-chemical environment and invertebrate fauna in the reservoirs are considered of secondary importance to the effects of competition among fish in the changes in species abundance and distribution.

ACKNOWLEDGMENTS

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The Alberta Department of Lands and Forests provided a vehicle, boat, and financial support for the study. My thanks go to provincial fishery biologists M.J.Paetz, R.C.Thomas, and E.B.Cunningham for their help throughout the study.

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I. INTRODUCTION

Recent changes in abundance and distribution of the fishes in the Kananaskis River system have occurred in conjunction with introductions of non-native fishes and hydro-electric developments. Previous studies on this system from 1936 to 1960 provide a good comparison for present observations.

Changes generally occur in fish populations when their biological and physico-chemical environment is altered. Elton (1958) gives examples of population declines in native species resulting from population explosions in introduced species. Larkin et al. (1959) give a general review of the effects of man-made activities on freshwater fisheries. It has been widely observed that construction of reservoirs causes a decrease in the number of catchable game fish but causes an increase in general productivity. Jenkins (1961) has outlined the problems of reservoir fish management and summarizes much of the past research. A United States Fish and Wildlife publication (1961) gives present-day topics of research and outlines those features best studied in reservoir research.

The information collected in this study will permit assessment of the changes and provide a basis for speculation as to the causes of the change. The results will contribute to the management of the game species and to an understanding of the natural history of the fish in the Kananaskis watershed.

The field work for this study was carried out during the summer of 1961. Field records and much of the collected material are in the Department of Zoology, University of Alberta, Edmonton, Alberta.

II. METHODS

The area studied extended from the Kananaskis Reservoir near Seebe, south along the Kananaskis River, to the tributaries of Upper Kananaskis Reservoir (Fig. 1).

Data were collected from May 8 to September 8, and from October 26 to October 28, 1961.

Limnological measurements were made weekly at Stations I and II on Barrier Reservoir (Fig. 2) and monthly on Lower and Upper Kananaskis reservoirs (Fig. 4). Temperature series were measured with a "Whitney Underwater Thermometer". Oxygen was determined by Miller's method (Miller, 1914). A Hellige comparator with phenol red-D was used to measure pH. Secchi's disk was used to give an index of light penetration. Mr. D.B.Fillion made an examination of the bottom fauna during the present study.

The temperature of the Kananaskis River, various tributaries, and beaver ponds were measured with a hand thermometer.

Fish were collected with gillnets, seines, dipnets, fykenets, and rotenone. Table 1 lists the gillnets used in the 1961 study. Table 11 shows the gillnet sampling of the reservoirs according to number of sets and net-hours. Nets were fished in given locations at various depths and times of the day throughout the season in Barrier Reservoir, in addition to general sets. Two-inch gillnets were set in Lusk, Tourist, Boundary, Powerline, and Grizzly beaver ponds.

Three seines, two 20 feet long and one 50 feet long of 0.5 inch stretched mesh, were used in the four reservoirs and in the streams throughout the study period. Weekly seining was conducted

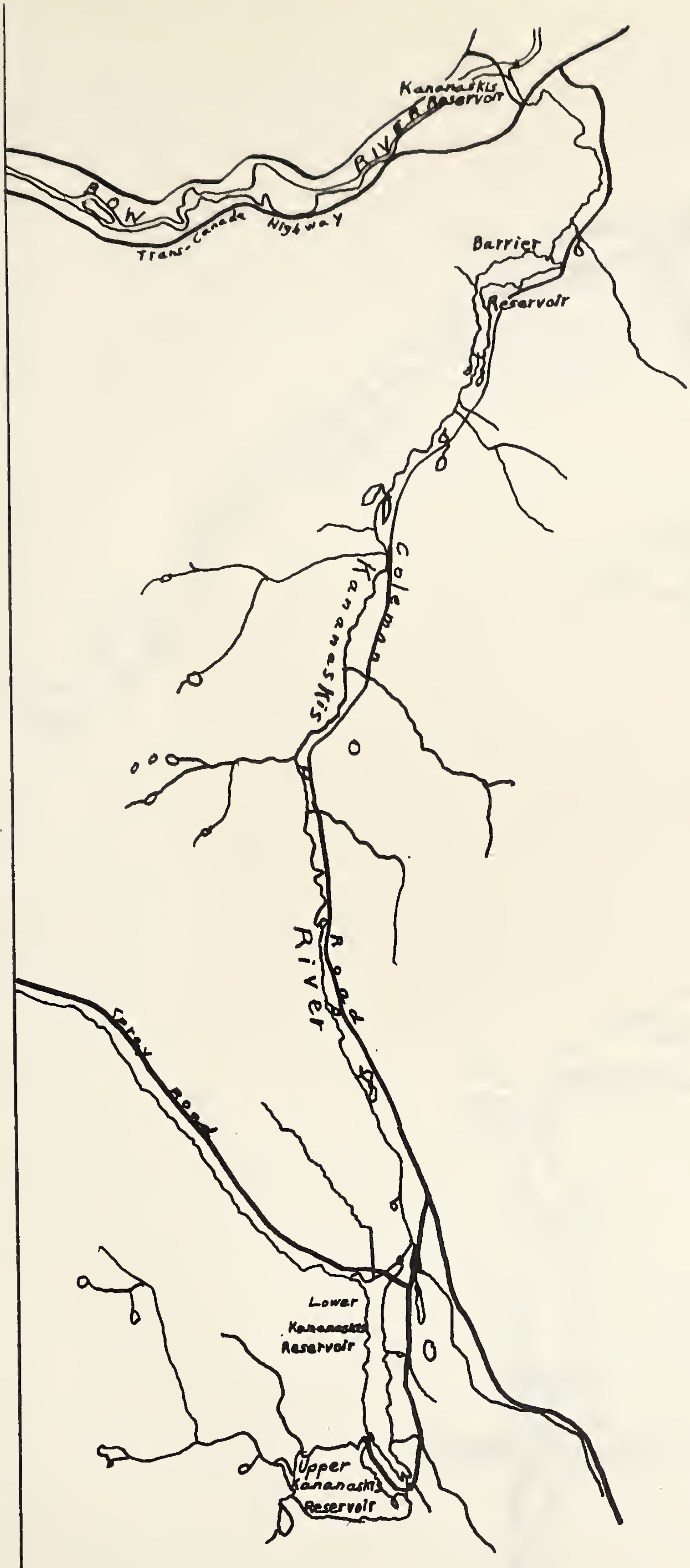

Fig. 1 Kananaskis River system and roads.

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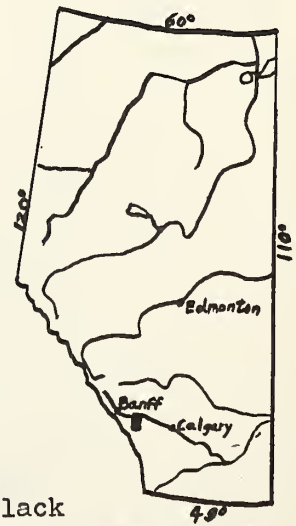

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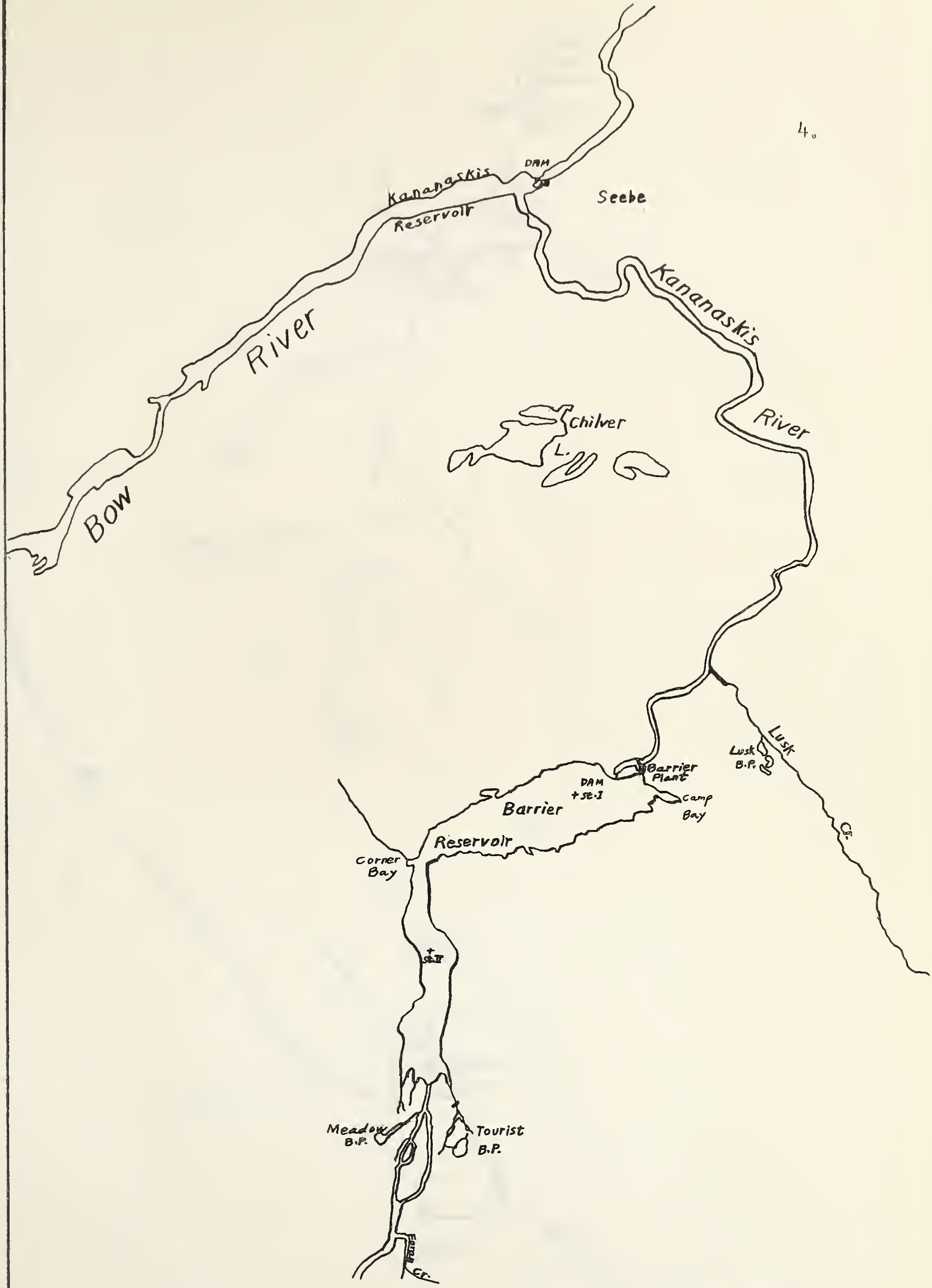

Fig. 2. Kananaskis Reservoir to Foran Creek

Scale 1 in. = 1 mi.

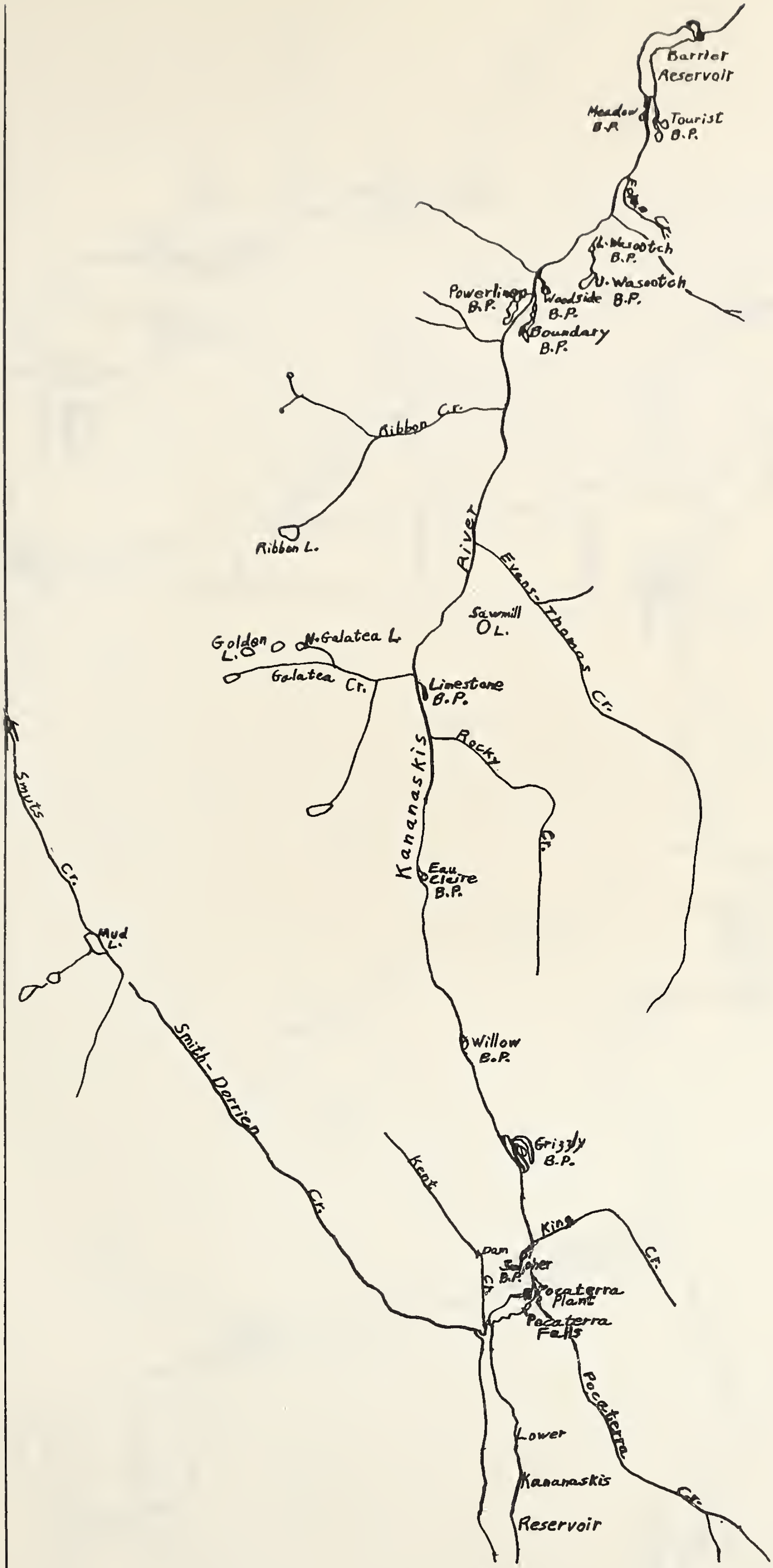

Fig. 3. Barrier Reservoir to Lower Kananaskis Reservoir.

Scale 1 in. = 3 mi.

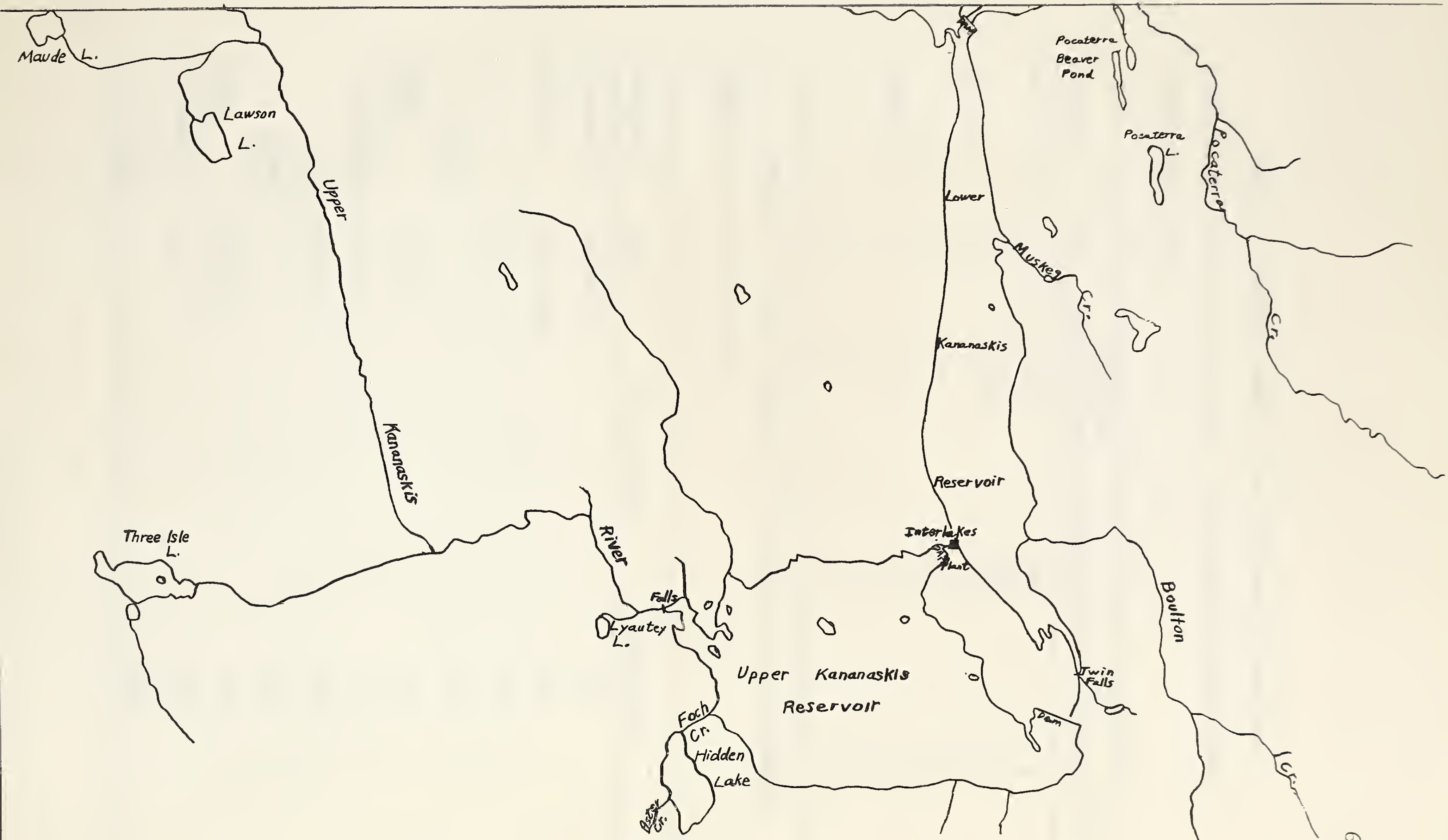

Fig. 4: Lower Kananaskis Reservoir to Hidden Lake.

Scale 1 in. = 1 mi.

Table I. Gillnets used in the 1961 study. Nets used prior to May 27 were braided nylon. Those used after May 27 were monofilament nylon.

Date	No.	Stretched Mesh (in in.)	Length (in ft.)	Depth (in ft.)
May 13-26	1	2.75	300	3
	1	3.5	150	6
	1	4.5	"	"
May 28 -	2	1	39.4	6
	2	3	"	"
	2	4	"	"
August 7 -	3	1.5	"	"
	3	2	"	"
	1	3	"	"
	1	4	"	"

Table II. Gillnet sampling of the reservoirs according to number of sets and net-hours.

Reservoir	Date	No. of Sets	Net Hours
Kananaskis	Aug.16-17	3	222
Barrier	May - Sept.	65	2627
	Oct.	2	290
Total		67	2917
Lower	June 10	1	36
Kananaskis	July 6-7	2	94
	Aug. 7-8	2	224
Total		5	354
Upper	July 7-8	1	78
Kananaskis	Aug. 8-10	3	270
Total		4	348

in the northeast area of Barrier Reservoir.

Dipnets of fine mesh were used in the reservoirs and beaver ponds.

Three fykenets were set in Barrier Reservoir.

Synergized rotenone (Chem Fish Special) was used in the river, creeks, and reservoirs. Seines and dipnets were used in conjunction with this poison.

The position of fishes in the gillnets were recorded, i.e., distance from shore and depth from cork line. Fork length, weight, and sex were recorded from these fish shortly after capture. Scale samples were taken two to four rows above the lateral line, below the dorsal fin. Gonads were weighed (wet weight) from representative samples taken throughout the season. Representative samples of whole fish (with body cavity slit) were preserved for later examination.

Fish caught in the fykenets were measured, weighed, sexed, and aged.

All fish seined, dipnetted, and collected with rotenone were preserved and measured, weighed, and aged during the winter. Stomach contents of preserved fish were also examined during the winter.

Data were collected from many fish from angler's creels.

The metric system was used for all measurements of fish and for all physico-chemical measurements of the various bodies of water. Geographical features are expressed in units of the English system, where such units are commonly expressed on maps and engineering data sheets.

III. PAST STUDIES

Earlier studies on the Kananaskis system provide evidence for changes in the abundance and distribution of the fishes and indicate the probable chronology of events.

Kananaskis Reservoir was examined by D.S. Rawson in 1938 and 1947 (Rawson 1939a, 1948). Barrier Reservoir was examined by Rawson in 1947, the year it was filled, and by J.R.Nursall in 1948, 1949, and 1960 (Rawson, 1948; Nursall, 1949, 1952, 1960). Lower Kananaskis Lake was examined by Rawson in 1936 and 1947 (Rawson, 1937, 1948) and R.B.Miller in 1954 (Miller, 1954a), during dam construction. R.C.Thomas made a post-impoundment study in 1957 (Thomas, 1957). Upper Kananaskis Reservoir was examined by Rawson in 1936 and 1947 (Rawson, 1937, 1948).

Several "old-timers" of the district also provided information concerning the past distribution of the fishes. Reports of fishery officers concerning the area were also examined.

IV. GEOGRAPHY AND POWER DEVELOPMENT

The Kananaskis River lies in the eastern area of the Rocky Mountains in south-western Alberta (Fig.1). It drains northward into the Bow River, which flows eastward into the Saskatchewan system of the Hudson Bay drainage.

The Kananaskis River is 52 miles long from Upper Kananaskis Reservoir to the Bow River. The drainage area of the river system is approximately 360 square miles (Nursall, 1949).

Mountain ranges averaging 7000 to 8000 feet in elevation, with a variety of gradual and precipitous slopes, border the

Kananaskis except in the lower five miles of the river where it breaks through into the foothills of the Rocky Mountains. The valley is U-shaped in cross-section with the valley floor varying from 100 yards to two miles in width.

A variety of plants occur along the streams. Lodgepole pine (*Pinus contorta*), western white spruce (*Picea glauca*), trembling aspen (*Populus tremuloides*), balsam poplar (*P. balsamifera*), birch (*Betula* sp.), willow (*Salix* sp.), and western choke cherry (*Prunus virginiana*) are common. Flowering plants, grasses, and mosses also occur throughout much of the area. The timber line is approximately 6,500 feet.

Crossley (1951) gives the annual precipitation for the lower Kananaskis area as 21 inches and the mean annual temperature as 38°F.

A drop of 1,325 feet from Upper Kananaskis Lake to the river mouth has afforded development of several storage and hydro-electric projects by Calgary Power Ltd. Water is stored in the reservoirs to give maximum annual flow for their adjacent power plants and for power plants along the Bow River. The Kananaskis power plants are generally not operated for a full 24 hour period and are often shut down for several days, during which time drainage is stopped from the adjacent reservoir.

Normally, Upper Kananaskis Reservoir is the first reservoir to be lowered in the winter, to meet downstream water commitments. When that reservoir nears its low water level, Lower Kananaskis and Barrier reservoirs are lowered respectively. Just prior to spring run-off, all three reservoirs are at their lowest level of the year.

They are raised during the period of high spring run-off (Fig.5). In this manner, the most efficient use of the water for hydroelectric power is attained.

Table III gives the physical characteristics of the reservoirs and Table IV gives various data on the associated power plants.

A. Kananaskis Reservoir (51° 05'N; 115° 04' W)

Kananaskis Reservoir is located near the town of Seebe at the confluence of the Kananaskis and Bow rivers (Fig.2). The reservoir extends along the basin of the Bow River and exhibits many characteristics of a river.

The forebay level fluctuates from 4196.0 to 4199.8 feet above mean sea level within the confines of steep banks. The area of 202 acres is therefore relatively constant. Water level is generally high in the summer but may fluctuate to the 3.8 foot extreme on a daily basis throughout the year. The plant is essentially a run-of-the-river type with spillway facilities but no storage.

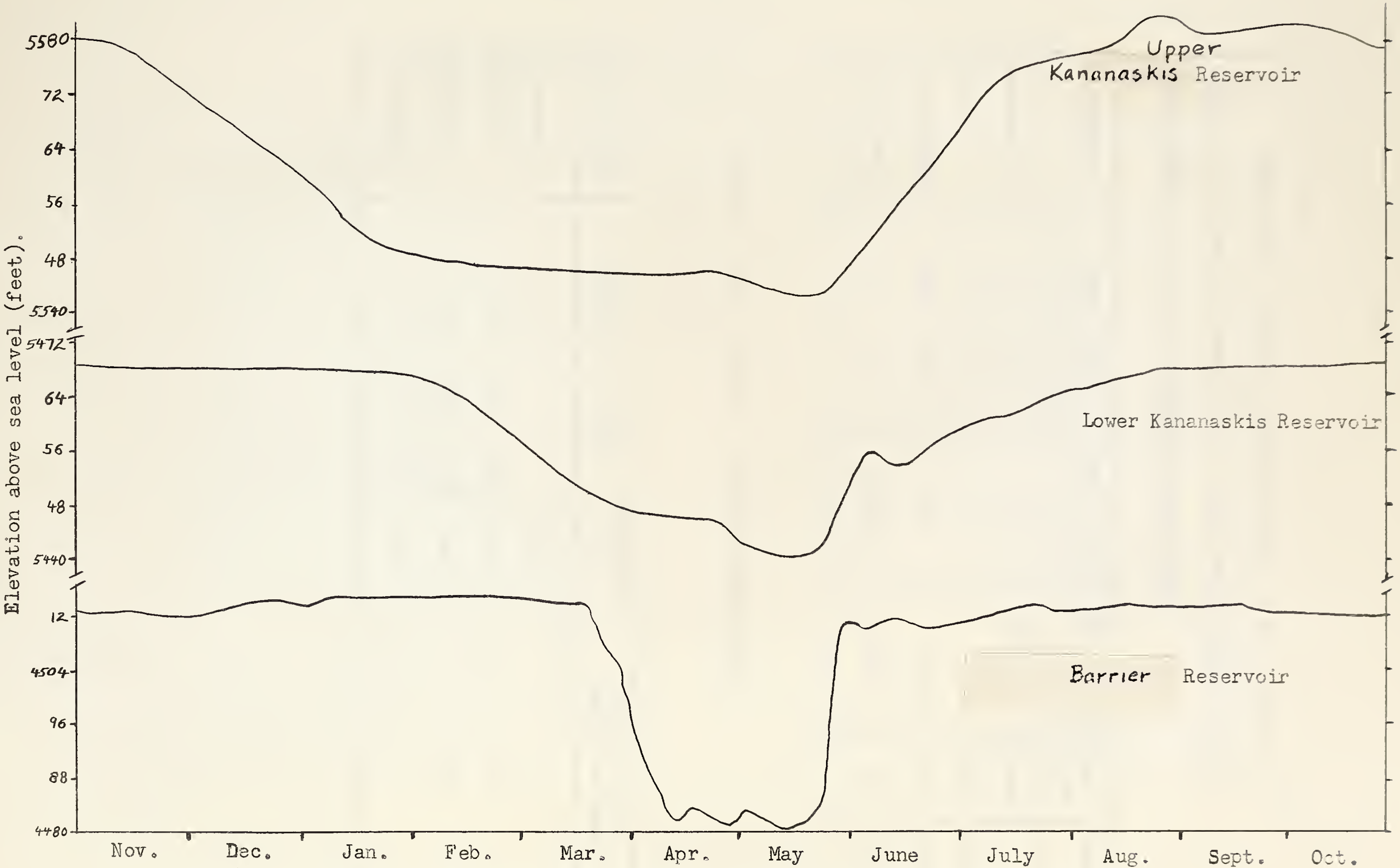

Fig. 5. Fluctuation in water level in Barrier, Lower and Upper Kananaskis reservoirs.

Table III. Physical characteristics of the reservoirs. (f.s.l. = full supply level, l.w.l. = low water level. Area in acres, depth in feet, and storage in acre feet).

Reservoir	Area f.s.l.	Area l.w.l.	Mean depth f.s.l.	Mean depth l.w.l.	Max. depth.	Storage
Kananaskis	202	201	6.5	unknown	unknown	-
Barrier	761	480	47	40	128	20,000
L.Kananaskis	1600	700	47	44.5	138	50,000
U.Kananaskis	2113	1565	unknown	unknown	328	95,400

Table IV. Power plants of the Kananaskis system. (k.w.h. = Kilowatt-hours).

Power plant	Year installed	Head feet	Capacity k.w.	Millions k.w.h. Yearly average.
Kananaskis	1913	72	10,000	95
Barrier	1947	150 to 120	13,000	45
Pocaterra	1955	215 to 170	15,000	29
Interlakes	1955	125 to 75	5,000	7

B. Barrier Reservoir (51° 01' N; 115° 04' W)

Barrier Reservoir is a main stem project eight miles from the mouth of the Kananaskis River, lying within the first slopes of the Rocky Mountains (Fig.2). Fig. 6 shows the outlet end and the earthfill dam. The river was raised from 4404 feet in elevation at the dam site in May, 1947. The reservoir is maintained at full supply level (f.s.l.) of 4515 feet elevation from freeze-up until early spring when a drawdown averaging 35 feet occurs over a two to three week period. The summer and early fall maximum is 4513 feet. Fig.7a shows the shoreline at low water level(l.w.l.) with ice still present on the reservoir. Fig. 7b and 7c show the inlet at l.w.l. and f.s.l. respectively.

The reservoir volume of 35,000 acre feet at f.s.l. is reduced by approximately 55% at l.w.l. Spillway facilities are present but seldom require use.

A more detailed description of this reservoir is provided by Nursall (1949).

C. Lower Kananaskis Reservoir (50° 31'N; 115° 08'W)

Pocaterra dam impounds Lower Kananaskis Reservoir (Fig. 4). This earthfill dam is 1.75 miles downstream from the former Lower Kananaskis Lake, or 44 miles upstream from the confluence of the Kananaskis and Bow rivers. The lake level was raised in June, 1955, from 5431 feet elevation to approximately the f.s.l. of 5469 feet in November of the same year. The dam permits a lowering of the lake level to 5426 feet, resulting in a maximum annual fluctuation of 43 feet. The

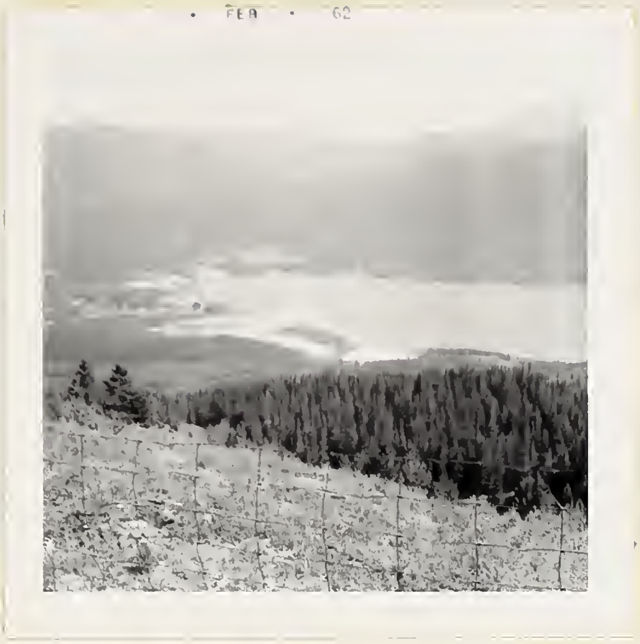

Fig. 6. Outlet end and earthfill dam of Barrier Reservoir, Kananaskis Forest Experiment Station in background. August 28, 1961.

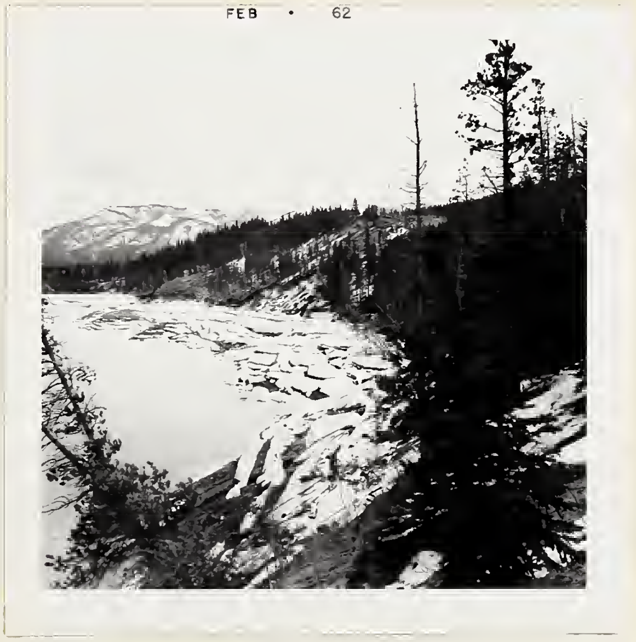

Fig. 7a. Shoreline of Barrier Reservoir at l.w.l. Note broken ice left behind at drawdown. May 9, 1961.

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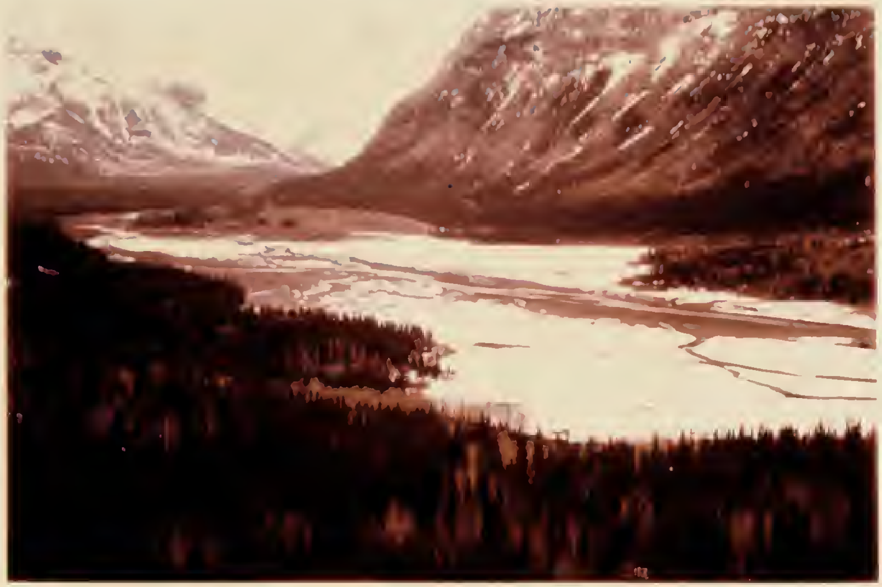

Fig.7b. Inlet end of Barrier Reservoir at l.w.l. The Reservoir has completely receded from its margins here. May 9, 1961.

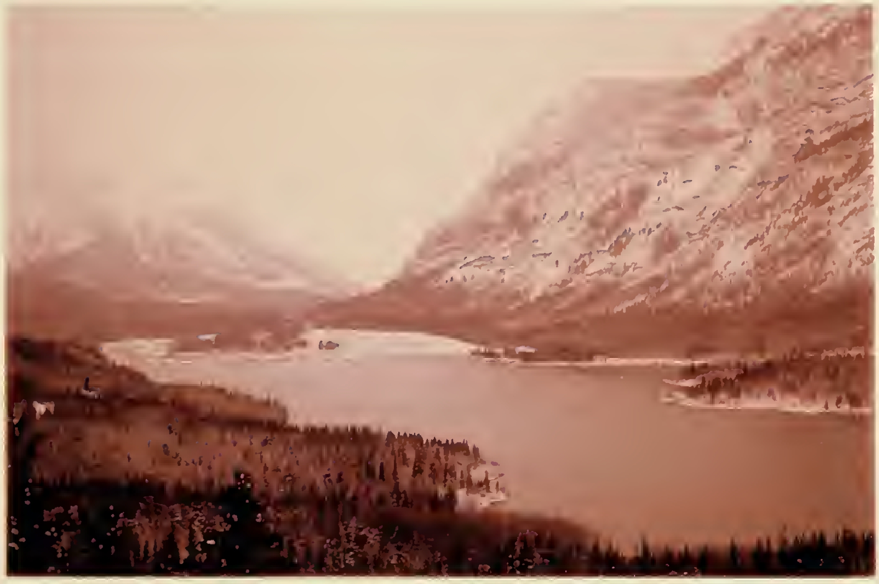

Fig.7c. Inlet end of Barrier Reservoir at f.s.l. October 27,1961.

volume at f.s.l. of 75,000 acre feet is reduced by approximately 60% at l.w.l.

Pocaterra plant is one mile downstream from the reservoir and the river has been diverted to pass through a canal to the power plant. No spillway facilities are present.

D . Upper Kananaskis Reservoir (50° 37' N; 115° 09'W)

Upper Kananaskis is the southernmost reservoir in the Kananaskis system and lies one mile upstream from Lower Kananaskis Reservoir, behind a hogback ridge (Fig.4). The outlet was deepened in 1932 to allow the original lake level of 5520 feet to be lowered to 5513 feet for storage purposes. Although earthfill had been placed over the outlet, it was not until 1936 that the f.s.l. of 5537 feet was utilized. In 1942, additional earthfill was placed over the old outlet and a new outlet was created, enabling the present f.s.l. of 5583 feet to be reached with l.w.l. at 5530 feet. The volume of this reservoir is not known, and Rawson's 1948 figures for the mean depths need revising.

In 1955 the Interlakes power plant (Fig.8) was installed on Lower Kananaskis Reservoir to utilize water from Upper Kananaskis Reservoir for power purposes, as well as for storage and flow control. Fig. 9 shows the outlet of the reservoir near the penstock. Regular spillway facilities are not present.

E . Kananaskis River

Kananaskis River is clear and fast flowing (Fig. 10). The gradient averages 28 feet per mile. Gravel, with stones two to eight inches in diameter, is common on the bottom.

Table V gives the mean monthly discharge in cubic feet per second (c.f.s.) of the Kananaskis River at Seebe prior to hydro-electric development. The daily starting and stopping of Barrier and Pocaterra power plants and irregular periods of longer shut down cause marked fluctuations in the river water level. The lowering of the reservoirs in the winter and spring causes abnormally high water for this period of the year (highest in late May and June in 1961, with 1700 c.f.s. not uncommon).

A pond exists below the Barrier dam spillway which joins the main river immediately below the powerhouse, 100 yards away. Fig. 11 shows Barrier power plant and tailrace. Fig. 12 shows the Kananaskis River immediately below the Barrier power plant.

The river for one mile below Lower Kananaskis Reservoir is fed only by seepage through the earthfill dam (about 4 c.f.s.). Outlet water is diverted through a canal to the Pocaterra plant. Pocaterra Falls (20 feet) and gorge are in this section of the river.

The river between Upper and Lower Kananaskis reservoirs is also fed only by seepage through the earthfill dam (about 0.5 c.f.s.). After 1932 this section of this river was subject to large fluctuations until 1942 when it was completely blocked off. A former 25 foot falls (Twin Falls) in this section of the river now lies at the f.s.l. shoreline of Lower Kanaskis Reservoir. No falls of any size is now present along the course of the river below the Pocaterra plant.

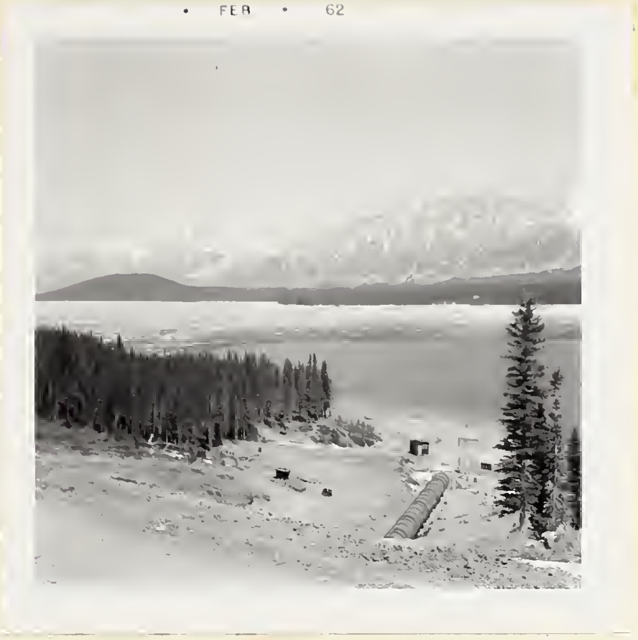

Fig. 8. Interlakes power plant on shore of Lower Kananaskis Reservoir. Note ice still on reservoir. May 23, 1961.

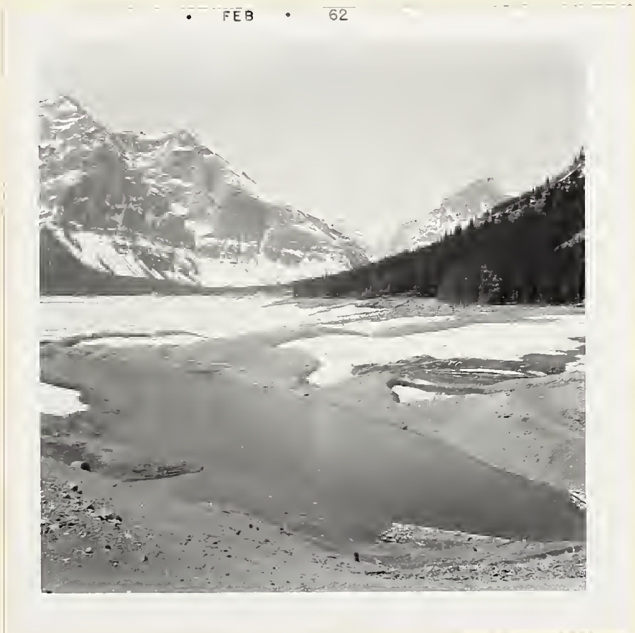

Fig. 9. Outlet end of Upper Kananaskis Reservoir at l.w.l. May 23, 1961.

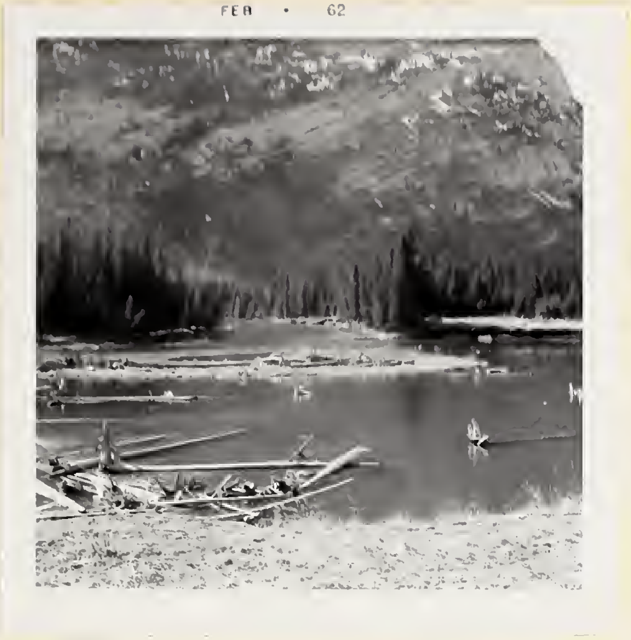

Fig. 10. Kananaskis River at high water near Eau Claire Beaver Pond. May 23, 1961.

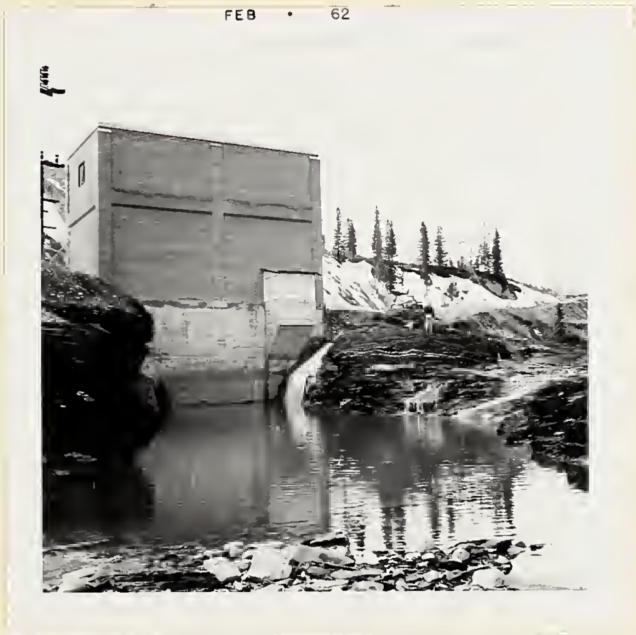

Fig. 11. Barrier power plant and tailrace. May 9,1961.

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Table V. Mean monthly discharge of Kananaskis River at Seebe prior to hydro-electric development (25 year average). Adapted from Rawson (1939).

Month	Discharge (c.f.s.)
Jan.	142
Feb.	134
Mar.	126
April	165
May	697
June	1830
July	1440
Aug.	980
Sept.	630
Oct.	369
Nov.	233
Dec.	180
Average	577

Table Vl. Estimated summer discharge of tributaries to Kananaskis River 1961 (estimates are those of author based on past experience).

Creek	Discharge (c.f.s.)
Lusk	30 - 40
Ribbon	40 - 120
Evans-Thomas	15 - 30
Rocky	15 - 25
Pocaterra	30 - 40
Smith-Dorrien	40 - 70
Boulton	20 - 40
Upper Kananaskis	70 - 100

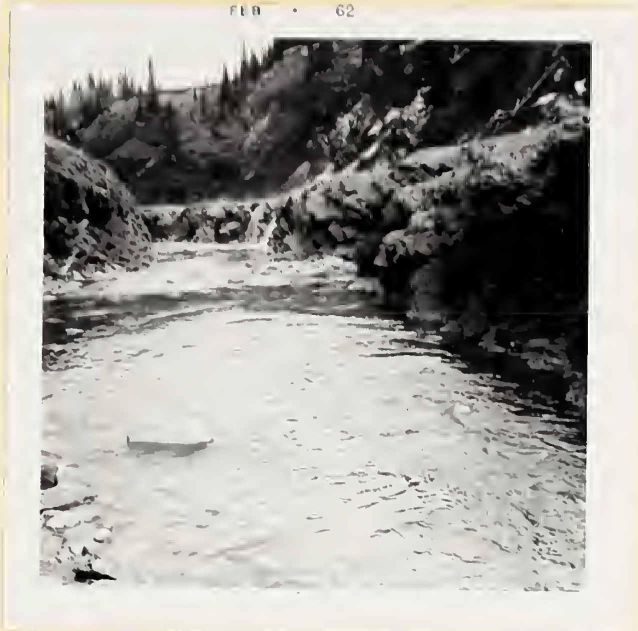


Fig. 12. Kananaskis River immediately below Barrier power plant. May 9, 1961.

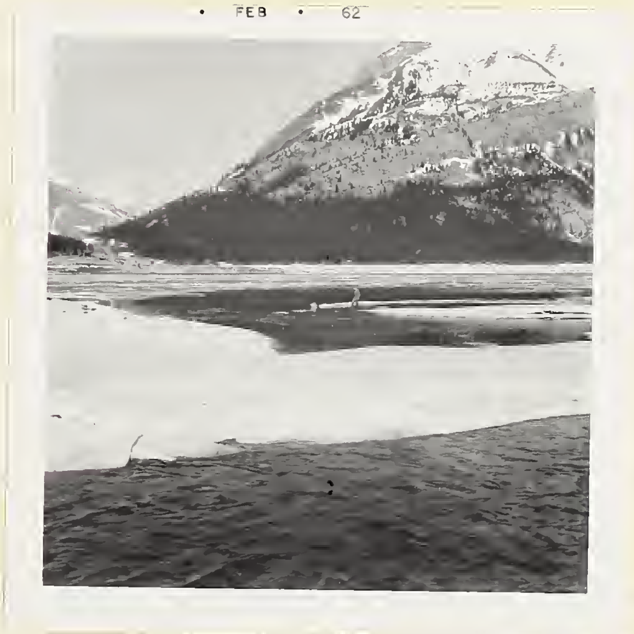


Fig. 13. Boulton Creek between l.w.l. and f.s.l. contours of Lower Kananaskis Reservoir. Note Interlakes power plant in distance and ice on reservoir. May 23, 1961.

[illegible]

[illegible]

F. Tributaries to Kananaskis River

Evans-Thomas and Rocky creeks have very swift currents and wide scoured flood channels. Lusk Creek has a moderate velocity with good side cover. Ribbon Creek tends to be swift and overflow its banks but has good side cover along much of its course. All have been unaffected by power development but logging operations may have contributed to faster run-offs in some areas.

The lower reaches of Pocaterra Creek have been diverted to re-enter the Kananaskis River through several channels over small falls further downstream than formerly. Gravel, with stones averaging one to three inches in diameter, forms the bottom. Side-cover is present.

G. Tributaries to Lower Kananaskis Reservoir

Kent Creek formerly drained into the Kananaskis River two miles downstream from Smith-Dorrien Creek. In 1956 it was diverted into Lower Kananaskis Reservoir where it enters over a 10 foot falls. Upstream from the falls is a stretch of slow-moving clear water. Maximum daily runoff is 60 c.f.s. while in the winter it may drop to near zero.

Smith-Dorrien Creek formerly drained into the Kananaskis River. Dam construction below the mouth of this creek resulted in it draining directly into Lower Kananaskis Reservoir. It is a clear stream with boulders up to two feet in diameter. In 1949, Mud Lake and its tributaries were diverted from Smith-Dorrien Creek into Spray Reservoir via Smuts Creek. In 1959,

French Creek was diverted from Smith-Dorrien Creek into Mud Lake. Some water has thus been diverted from the Kananaskis drainage into the Spray.

Boulton Creek (Fig. 13) is clear with good side cover, deep pools, and small gravel. Beaver dams and logs cross its lower reaches. A small (but probably impassable) falls exists within 200 feet of h.w.l. of Lower Kananaskis Reservoir.

H . Tributaries to Upper Kananaskis Reservoir

Upper Kananaskis River flows over a 30 foot stepped falls into Upper Kananaskis Reservoir at f.s.l. The reaches below this falls at l.w.l. are turbulent and opaque. Prior to the 1942 impoundment, the river flowed for 3600 to 5400 feet below the falls into Upper Kananaskis Reservoir. Three-Isle, Maude, and Lawson lakes are in the headwaters of this silty river. Small gravel, with stones one inch in diameter, moderate current, and good side cover are characteristic of the lower reaches.

Foch Creek prior to the impoundment of Upper Kananaskis Lake drained into Upper Kananaskis River, but now flows directly into Upper Kananaskis Reservoir. Hidden Lake was formerly drained underground by Foch Creek but a landslide around 1946 (per. comm. J. Kovach) has blocked this passage, resulting in a surface drainage and a rise in the lake level of about three feet. Several other smaller creeks enter Upper Kananaskis Reservoir over falls.

Table Vl gives the estimated discharge of the larger tributaries in the Kananaskis drainage.

I . Beaver Ponds

Beaver ponds (Fig. 2 and 3) are numerous in the Kananaskis valley and form stable environments. The bottom consists of soft mud with

gravel rare or absent. Many beaver ponds consist of several ponds, i.e., Lusk, Tourist, *Powerline* (see Frontispiece), *Boundary*, and Grizzly (the latter two have more than 15 ponds). The above beaver *ponds* and Upper and Lower Wasootch, are up to six feet deep. Other beaver ponds are generally less than three feet deep.

V. PHYSICO - CHEMICAL CONDITIONS

A comparison of past and present conditions in the Kananaskis system can be made in the physico-chemical conditions from data collected during the past 25 years.

A. Temperature

Kananaskis Reservoir is under the cooling influence of the Bow River. It is unlikely that any significant temperature change has occurred in this reservoir since it was built in 1913. Rawson (1948) gave the summer temperature range as 8.0 to 11.5°C.

Barrier Reservoir provides a body of warm water along the normally cold Kananaskis River. Fig. 14a and 14b show the 1961 summer distribution of isotherms in the southern and eastern arms, respectively. On May 12, surface to bottom temperatures varied from 4.2 to 3.9°C respectively, while on October 27 comparable readings were 3.5 to 3.8°C. The marked cooling of the epilimnion and warming of the hypolimnion in early July was likely caused by an overturn initiated by strong winds on June 30. Mid-day surface shore temperatures ranged from 16 to 21°C. The reservoir generally freezes in November. In 1961 it became completely ice-free on May 18.

Temperature series from Lower and Upper Kananaskis reservoirs are included in Fig. 14b. Mid-day surface shore temperatures in Lower Kananaskis Reservoir ranged from 18 to 23°C while comparable

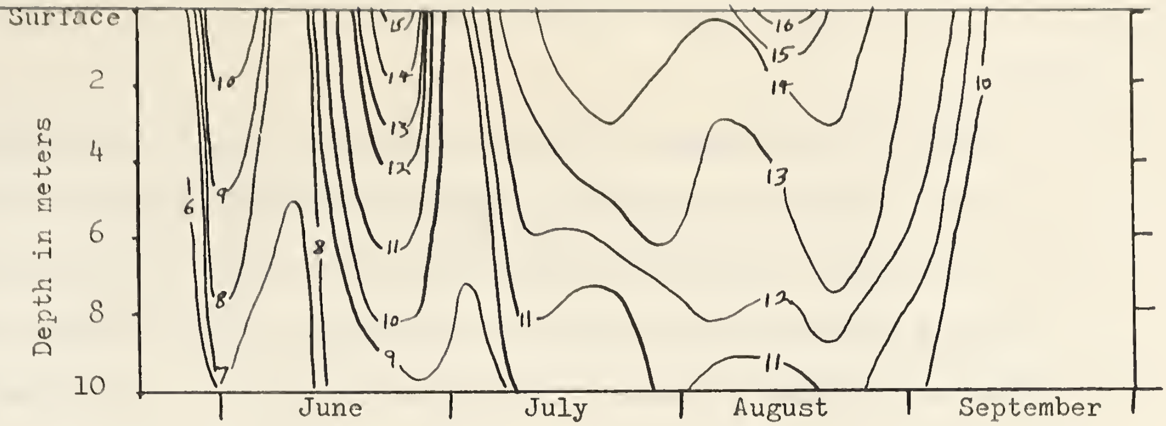


Fig. 14a. Summer distribution of isotherms in southern arm, Barrier Reservoir (Temp. in degrees centigrade).

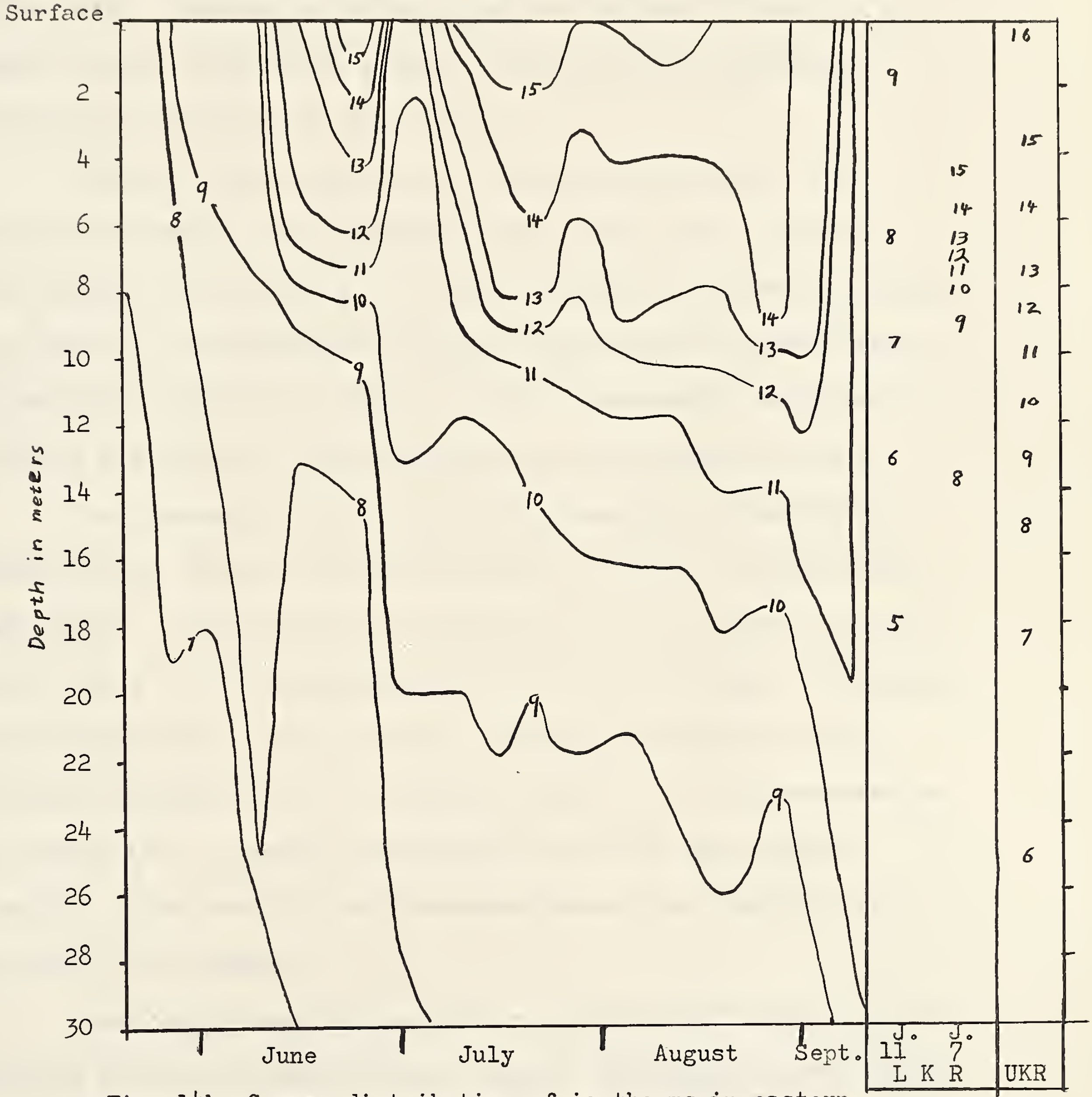


Fig. 14b. Summer distribution of isotherms in eastern arm, Barrier Reservoir. June 11 and July 7 temperature series for Lower Kananaskis Reservoir (LKR) and August 11 series for Upper Kananaskis Reservoir (UKR) are included.

temperatures in Upper Kananaskis Reservoir ranged from 17 to 22°C. Lower and Upper Kananaskis reservoirs are generally warmer in the epilimnion and colder in the hypolimnion than Barrier Reservoir. The sharper thermal stratification of the former reservoirs may be a result of the smaller flushing rate, compared to Barrier Reservoir. Localized ice sheets were still present on both reservoirs at the end of May, 1961. Temperature series taken over the past 25 years do not suggest that any significant change in Lower and Upper Kananaskis reservoirs has occurred in that period.

During the summer months, the outlet of Lower Kananaskis Reservoir is beneath the thermocline. The outlet water temperature would unlikely rise above 11°C. Surface drainage from Lower Kananaskis Lake, prior to dam construction, probably approached the lake surface temperature of about 15 or 16°C., but would subsequently have been cooled by the inflow of cold tributaries to the Kananaskis River.

The Kananaskis River between Lower Kananaskis Reservoir and Pocaterra plant varied in temperature from 10 to 13°C. Certain pools reached 17°C. The river between Pocaterra plant and Barrier Reservoir varied from 8 to 10°C in May and 10 to 12° C in the summer. Tributaries such as Evans-Thomas, Smith-Dorrien, Pocaterra, and Boulton creeks, and Upper Kananaskis River, had highs of about 10°C. Side-channels in all reached 12°C. In May, Boulton and Foran creeks were between 2 and 5°C. Lusk Creek and the Kananaskis River below Barrier were about 14°C in the summer.

Beaver pond temperatures rose to a high of 24°C in the shallow zones and 22°C in the deeper areas. Many of the Boundary beaver ponds, however, only reached 12°C.

B. Oxygen concentration.

The large inflow and strong wind action keeps the reservoirs well oxygenated. During 1961 no $[O_2]$ less than 5 cc/l was observed. Nursall (1949) reported the bottom $[O_2]$ in Barrier Reservoir as 5.5 cc/l for January, 1948,and 4.0 cc/l for January, 1949. Rawson (1937) recorded a low of 3.8 cc/l (53% saturation) for Lower Kananaskis Lake in August, 1936. It is unlikely that any significant change in the oxygen concentration of the reservoirs has occurred in the last 25 years.

C. Hydrogen ion concentration

The p^H of the Kananaskis system is generally alkaline (Table Vll). The consistent and relatively acid readings obtained by Miller (1954a) and Thomas (1957) are in error (per.comm.R.C.Thomas) and are therefore not included.

No change in p^H was noted during the flooding of Barrier Reservoir by Nursall (1949). In the summer of 1961, the p^H varied from 7.4 to 8.4.

There is no evidence that raising Lower Kananaskis Lake changed the p^H.

Table VII. Hydrogen ion concentration in the four reservoirs (1936-1961). * denotes values averaged from many readings.

	1936	June 1947	July 1947	Aug. 1947	1948	June 1961	July 1961
Kan. Res.							
surface		7.9		8.0			
bottom		7.9		8.0			
Barrier Res.							
surface		7.9*	8.2*	8.1*	8.3*	8.2*	8.2*
bottom		7.8*	7.7*	7.8*	8.2*	8.1*	7.9*
L.Kan.Res.							
surface	8.1		8.1	8.2		8.0*	8.2*
bottom	7.7		7.9	7.9		7.7*	8.2*
U.Kan.Res.							
surface	8.0		7.8	8.1			7.9
bottom	7.7		7.5	7.6			7.6

Table VIII. Secchi disk reading in the four reservoirs (1936-1961). * denotes values averaged from many readings. Values in meters.

	1936	June 1947	July 1947	July 1961
Kan. Res.		1.1	1.4	
Barrier Res.		2.3*	3.0*	2.0*
L. Kan. Res.	4.5	9.0	13.2	6.3
U. Kan. Res.	2.2	6.0	8.5	3.3

D. Light penetration

A rough index of light penetration has been obtained with Secchi's disk. The order of increasing transparency of the reservoirs is: Kananaskis, Barrier, Upper Kananaskis, and Lower Kananaskis (Table VIII). Lower Kananaskis Reservoir lacks the silty tributaries that are common to Upper Kananaskis and Kananaskis reservoirs. The greater depth of the former allows the silt to settle out whereas it remains in suspension in the latter. The large inflow into Barrier also tends to keep silt in suspension.

No shift in range of light penetration is evident from past studies for any of the reservoirs.

VI. PLANKTON AND BENTHOS

Rawson (1948) described the Kananaskis Reservoir plankton as sparse and fluviatile. He found oligochaete worms dominating the bottom fauna while sphaeriid clams and chironomid larvae were common. There is no reason to suspect that any change has occurred since the time of Rawson's study.

Nursall (1949) stated that establishment of plankton was rapid in Barrier Reservoir after its formation. The population was, and has remained, sparse (Nursall, 1960). The dominance of rotifers, common occurrence of the crustaceans Bosmina, Diaptomus, and Cyclops, and the algae Asterionella and Fragilaria are unchanged from 1947. The algae Ceratium and Dinobryon, not reported present by Nursall(1949), are now common. D.B.Fillion (per.comm.) states that chironomids, oligochaetes, and the clam Pisidium, form the dominant benthic fauna now. Pisidium was not reported by Nursall in 1949 but was in

1960. The appearance of this organism is the only known major change in the benthic fauna. With the formation of Barrier Reservoir, a river fauna characterized by stoneflies (Plecoptera), and Mayflies (Ephemeroptera), has been changed to a relatively richer benthic and planktonic fauna as given.

Rawson (1937, 1948) and Miller (1954a) reported the plankton in Lower Kananaskis Lake to consist mainly of the protozoan *Ceratium*, the copepod *Diaptomus*, and the diatom *Asterionella*. Thomas (1957) noted an increase in *Cyclops* and *Daphnia* and a decrease in a large species of *Diaptomus*, The latter was also reported to decrease in abundance after impoundment and water level fluctuations took place in other reservoirs. A small species of *Diaptomus* was still present in 1961. Little volumetric change in the plankton has occurred since the damming of the lake in 1955 (Thomas, 1957). Indeed, fluctuating waters are generally not as harmful to plankton as they are to benthos. Rawson (1937,1948) reported that chironomids, sphaeriids; oligochaetes, and *Gammarus* dominated the benthos. Miller (1954a) reported much the same. Thomas (1957) noted a marked decrease in the bottom fauna over the newly flooded area (upper 37 feet). The original lake bottom remained unchanged from the time of Miller's study. Chironomids, oligochaetes, and *Gammarus* were reported as the principal bottom fauna. Miller (1954a) and Thomas (1957) predicted that the only bottom form likely to remain in abundance would be the chironomids. D.B.Fillion (per. comm.) states that chironomids dominate the flooded areas but sphaeriid clams and oligochaetes are still common. The shore zone is, however, generally poor in fauna. Miller (1954a) reported that chironomids can overwinter on exposed areas and Fillion adds that recently flooded areas contain

larvae. Chironomids are thus well adapted to these fluctuating reservoirs. Thomas (per.comm.) states that Lower Kananaskis Lake lacked rooted aquatics before impoundment. The same condition exists now, as in all the reservoirs.

Rawson (1937, 1948) reported a small Diaptomus and green alga Dictyosphaerium (in 1948 only) as the dominant plankters in Upper Kananaskis Reservoir. In 1936 algae were scarce and only representated by two diatoms, Asterionella and Fragillaria. Rawson (1948) found chironomids, and to a lesser exent, oligochaetes, and sphaeriids in the benthos. He gave evidence that sphaeriids and Gammarus had decreased while oligochaetes had increased in abundance since 1936. Rawson (1937) regarded Upper Kananaskis Reservoir as quite barren and less productive than Lower Kananaskis Lake. Fillion (per.comm.) states that Lower and Upper Kananaskis reservoirs are now similar in bottom fauna.

Stoneflies and mayflies occur in the streams, dance flies (Empididae) and chironomids occur in the tailrace of the Barrier plant and in certain streams. Gammarus is abundant in the many sloughs of slow-moving water that enter the southern end of Barrier Reservoir. It seems improbable that river fluctuations would be deleterious to insect larvae.

Beaver ponds have a rich and varied fauna. Snails, clams, beetles, back-swimmers (Notonectidae), chironomids, and ants (Formicidae) were noted. Rooted aquatics are often present and provide cover for trout in Tourist Beaver Pond.

VII. FISH STOCKING

Fish stocking has been carried out on a regular basis in the Kananaskis system since 1935 (Table IX). Some earlier and unauthorized introductions were made.

The only recorded introduction of brown trout (*Salmo trutta*) in the Bow system was made in 1925. At this time 45,000 fingerlings were released in Carrot Creek, a tributary to the Bow River 21 miles upstream(west) from the mouth of the Kananaskis River. These brown trout were reared at the Banff hatchery from eggs shipped in the fall of 1924 from the Norris hatchery in Montana. The stock probably originated in the British Isles (per. comm. Dept. of Fisheries, Ottawa).

Adult cutthroat trout (*Salmo clarki*) were unsuccessfully introduced into Upper Kananaskis Lake in 1914 from spawning stocks taken below the falls between Upper and Lower Kananaskis lakes (per.comm. J. Naylor). Previously barren Ribbon Lake was stocked in 1920 with cutthroat fry. Eggs were obtained from native Spray Lake stocks and reared in the Banff hatchery (per. comm. J. Naylor).

Gilmour (1950) states that trout from Lower Kananaskis Lake used in the past for restocking the Kananaskis lakes and other Alberta lakes were a hybrid (*Salmo clarki* x *gairdneri*). Reciprocal crosses were made intentionally at times (per. comm. J. Kovach).

A number of unauthorized introductions of lake chub (*Hybopsis plumbea*), longnose dace (*Rhinichthys cataractae*), longnose sucker (*Catostomus catostomus*), and white sucker (*C. commersoni*), probably all of Bow River origin, have been made by anglers. These fish have been used as live bait by anglers. This usage was not made illegal until 1957.

Table IX. Fish stocking in the Kananaskis system (1935 - 1961).

Species	1935	1936	1937	1938	1939	1940	1941
Rainbow trout	U.Kan. Res.	...	...	...	...	Foran Cr. Ribbon Cr. Kan. R. Boundary dams. Misc. dams.	U.Kan.Res. Ribbon Cr. Misc.Cr.
Cutthroat trout	...	L. Kan. Lake Pocaterra Cr. Boulton Cr.	...	...	Kan.R. Misc.Cr.		Misc.Cr.

Species	1942	1943	1944	1945	1946	1947	1948
Rainbow trout	...	Kan.R.	U.Kan.Res. L.Kan.Lake Pocaterra Cr Boulton Cr. Kan.R.	Hidden Lake	...	BoultonCr. Misc. Cr.	...
Cutthroat trout	...	...	...	...	...	...	...

Table IX (cont.)

Species	1949	1950	1951	1952	1953	1954	1955
Rainbow Trout	...	U. Kan. Res.	...	...	...	...	Pocaterra Lake
Cutthroat trout	...	...	Barrier Res	Moose Cr. Muskeg Cr. Evans-Thomas Cr. Lusk Cr. dam.	Rocky Cr.	...	...
Brook trout	...	...	Pocaterra Cr.	...	...	...	...

Species	1956	1957	1958	1959	1960	1961
Rainbow trout	Kan. R. dams	...	...	L.Kan.Res.	...	...
Golden trout	...	...	...	...	Three Isle Lake	Three Isle Lake
Cutthroat trout	...	...	...	...	..	N.Galatea Lake
Brook trout	Kan. R. dams.	...	...	Lusk Cr.dam Powerline dam Wasootch dam	...	Powerline dam Wasootch dam

Plantings of brook trout (*Salvelinus fontinalis*), rainbow trout (*Salmo gairdneri*), Atlantic salmon (*S. salar*), cisco (*Coregonus artedii*), lake whitefish (*Coregonus clupeaformis*), smallmouth bass (*Micropterus dolomieui*), and mosquitofish (*Gambusia affinis*) have been made in the upper Bow River (Rawson, 1939b; per. comm. J.C.Ward). Only the Atlantic salmon and smallmouth bass introductions were unsuccessful.

VIII. DISTRIBUTION OF THE FISHES

Eleven species of fish occur in the Kananaskis system. Of these eleven, only mountain whitefish (*Prosopium williamsoni*), longnose dace (*Rhinichthys cataractae*), and brook stickleback (*Eucalia inconstans*) have remained generally unchanged in their distribution over the past 25 years. Fig. 15 to 25 show the "past and present" distribution of the fishes. Past distributions are based on the 1947 study of Rawson (1948) and the 1948-49 study by Nursall (1949) of Barrier Reservoir. Present distribution denotes areas invaded or stocked since 1947 (1949 for Barrier Reservoir). Rare denotes areas where only a few specimens were taken in 1961. The native distribution in North America and eastern Siberia is shown on the inset map for each species. In Fig. 19 and 20 the presence of hybrids (*Salmo clarki* x *gairdneri*) is not considered. Specimens are classified according to the species they resemble most. Table X shows the species of fishes gillnetted in the reservoirs from 1936 to 1961. Generally, in all surveys nets were set in several localities within each reservoir. Because of the uniformity of habitat and a relatively uniform distribution of the

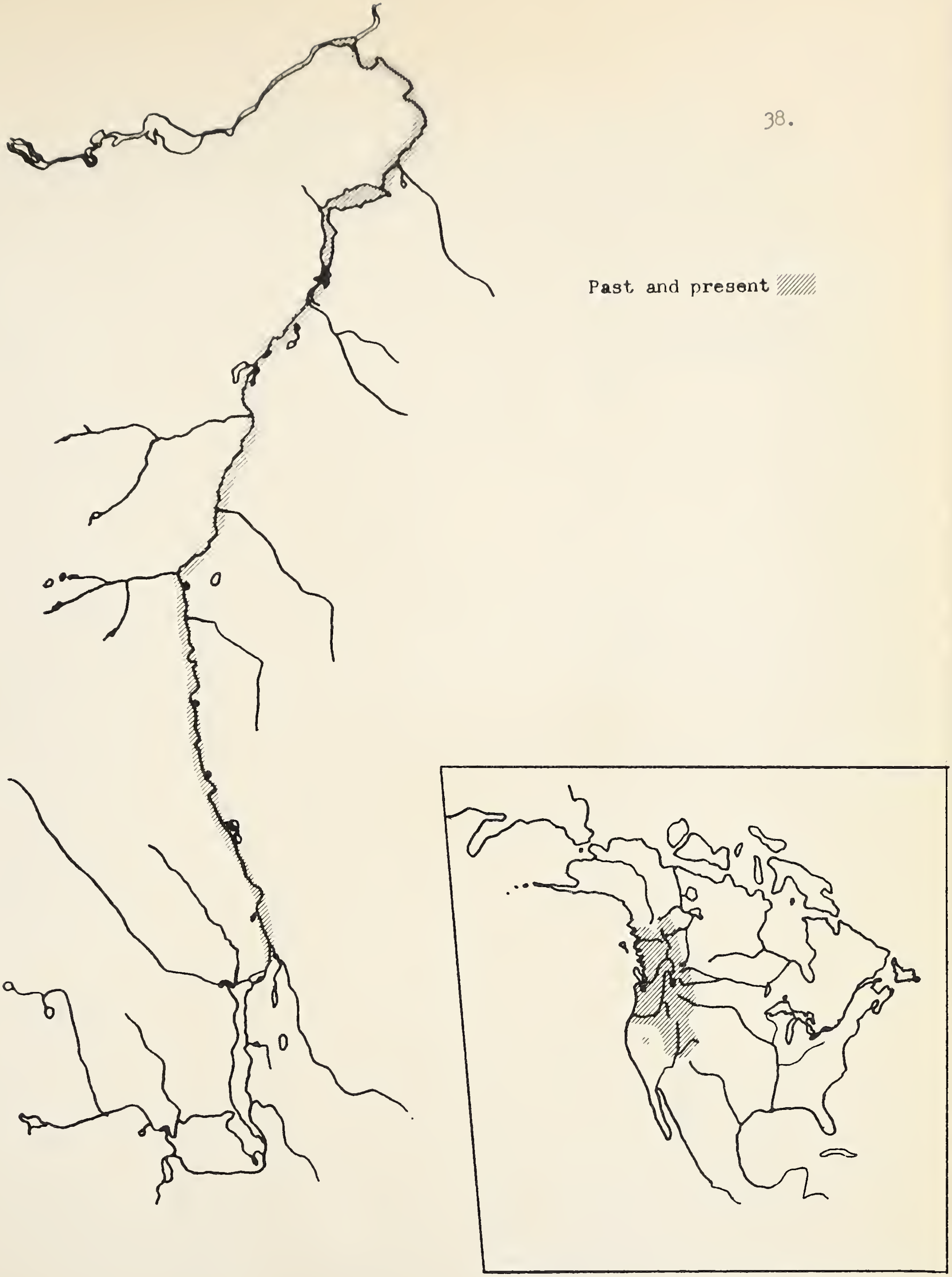


Fig. 15 Distribution of mountain whitefish (Prosopium williamsoni).

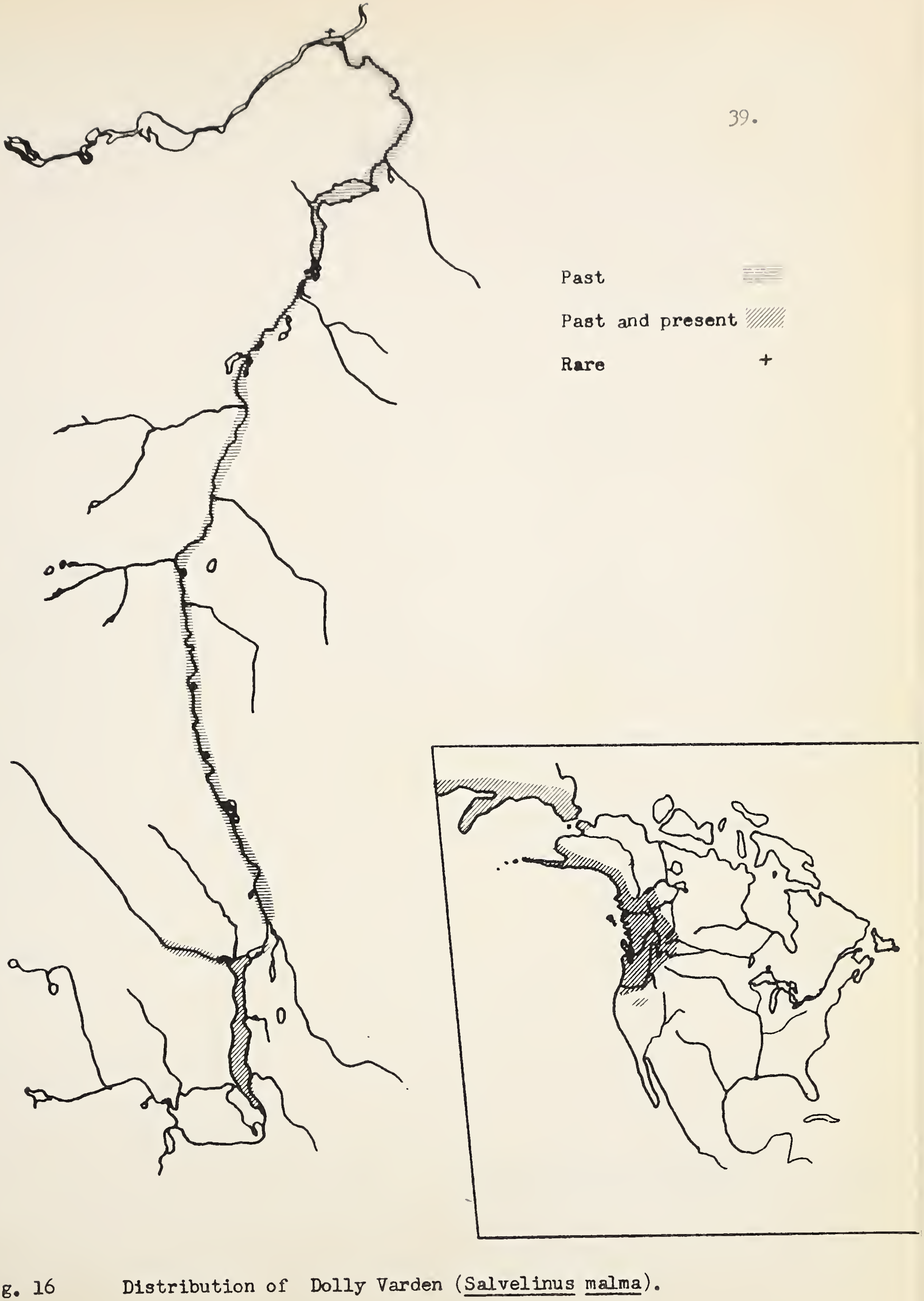
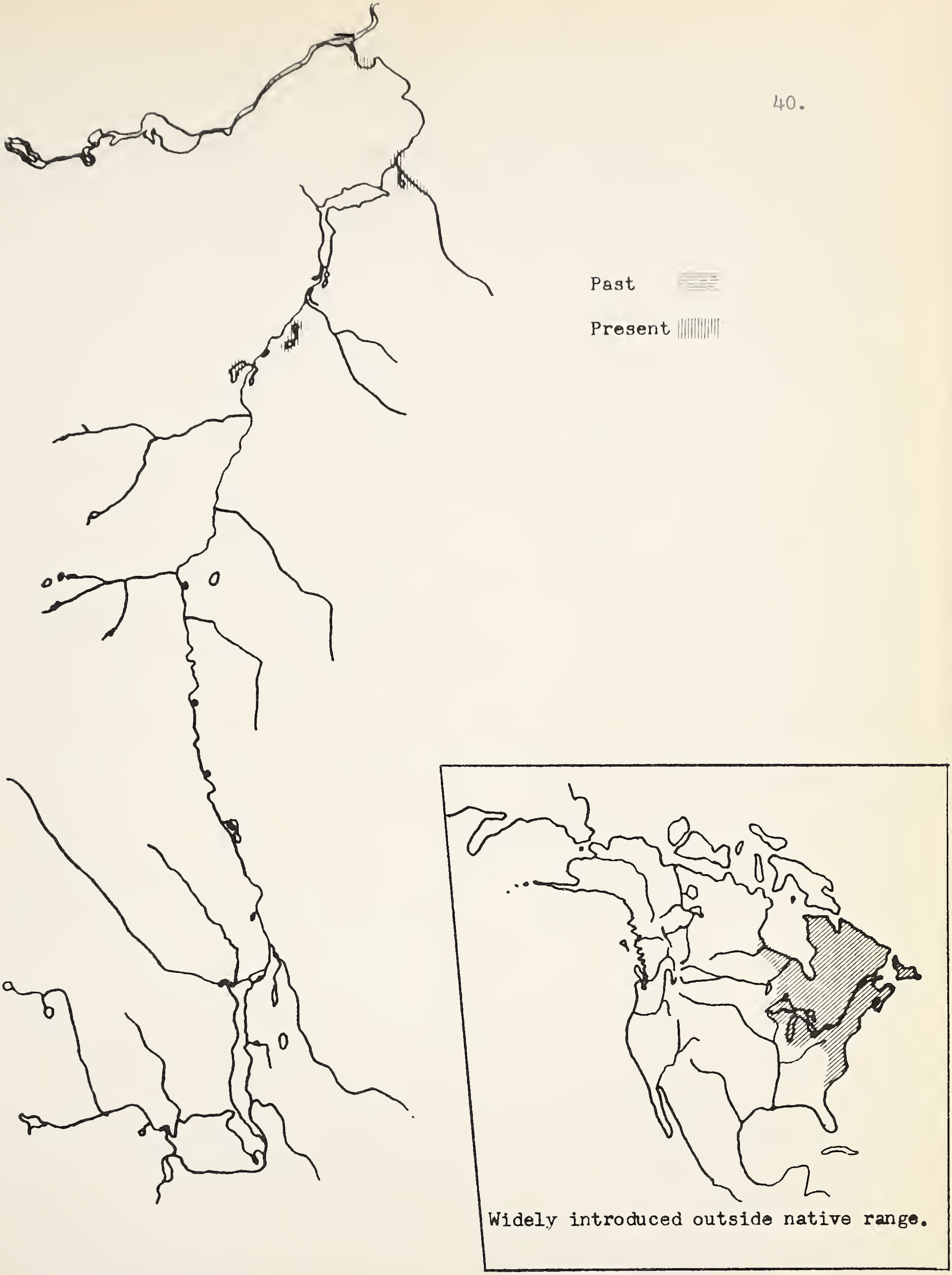
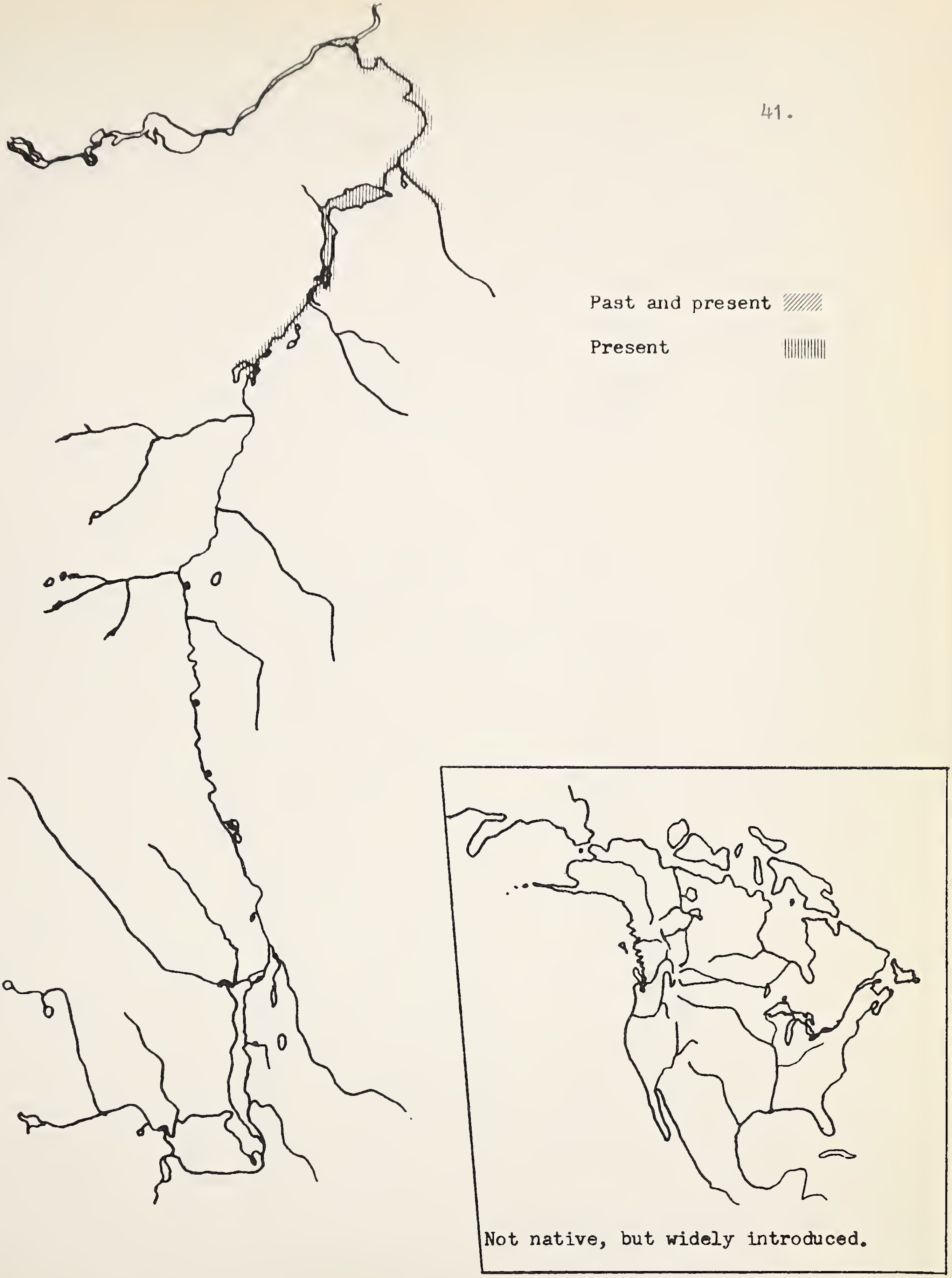


Fig. 16 Distribution of Dolly Varden (Salvelinus malma).



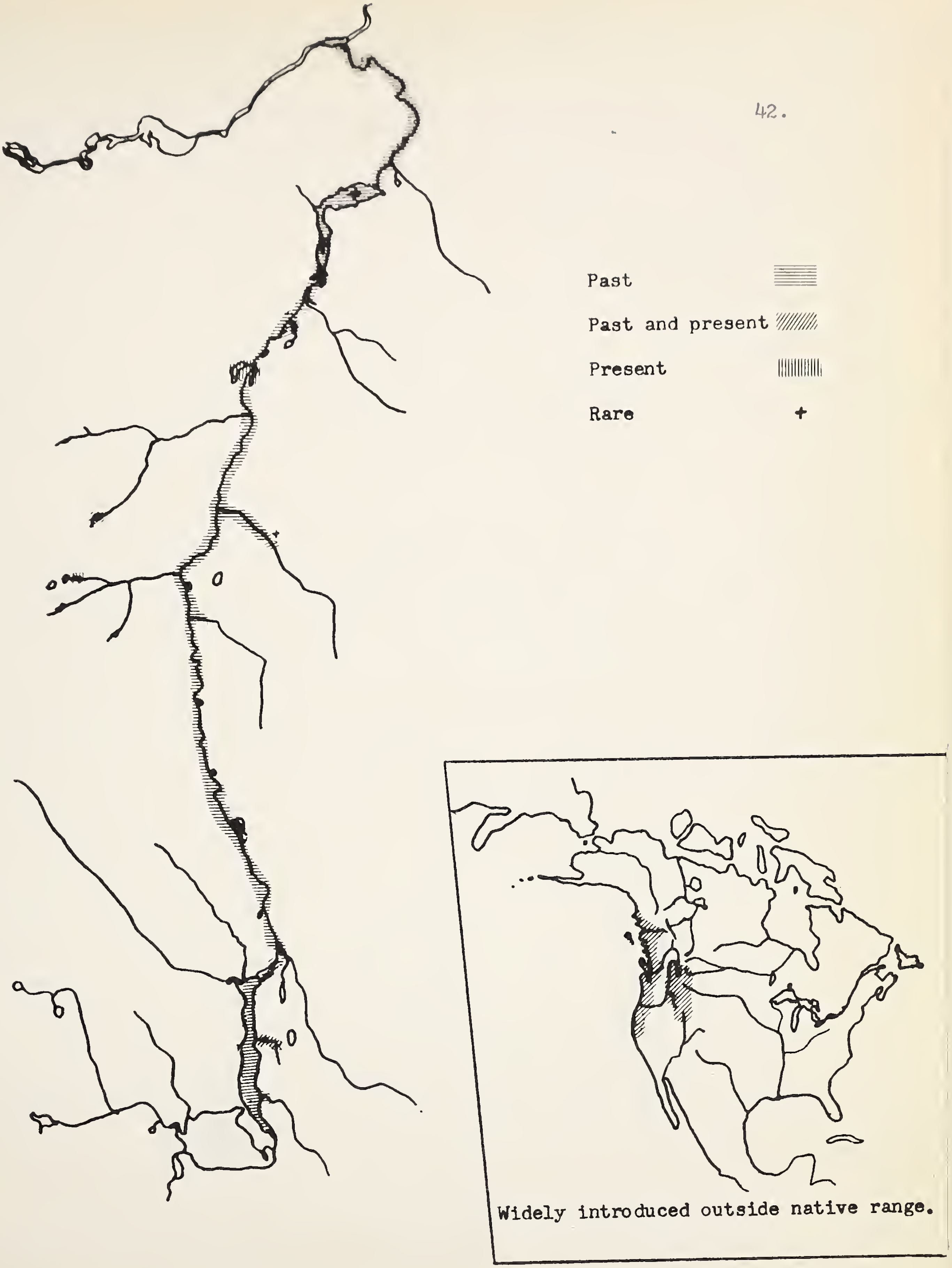
Widely introduced outside native range.

Fig. 17 Distribution of brook trout (Salvelinus fontinalis).



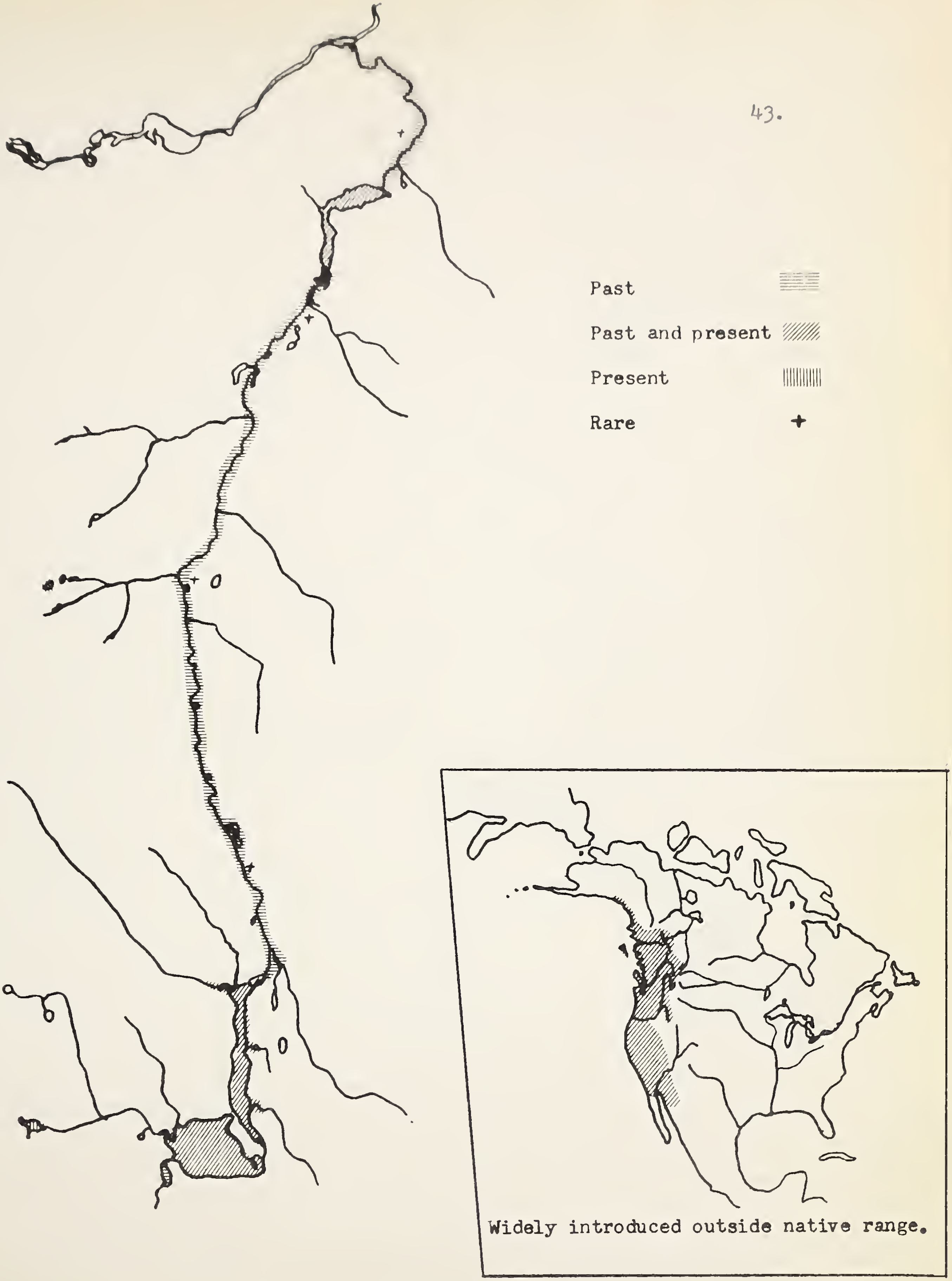
Not native, but widely introduced.

Fig. 18 Distribution of brown trout (*Salmo* *trutta*).



Widely introduced outside native range.

Fig. 19 Distribution of cutthroat trout(*Salmo clarki*).



Widely introduced outside native range.

Fig. 20 Distribution of rainbow trout (Salmo gairdneri).

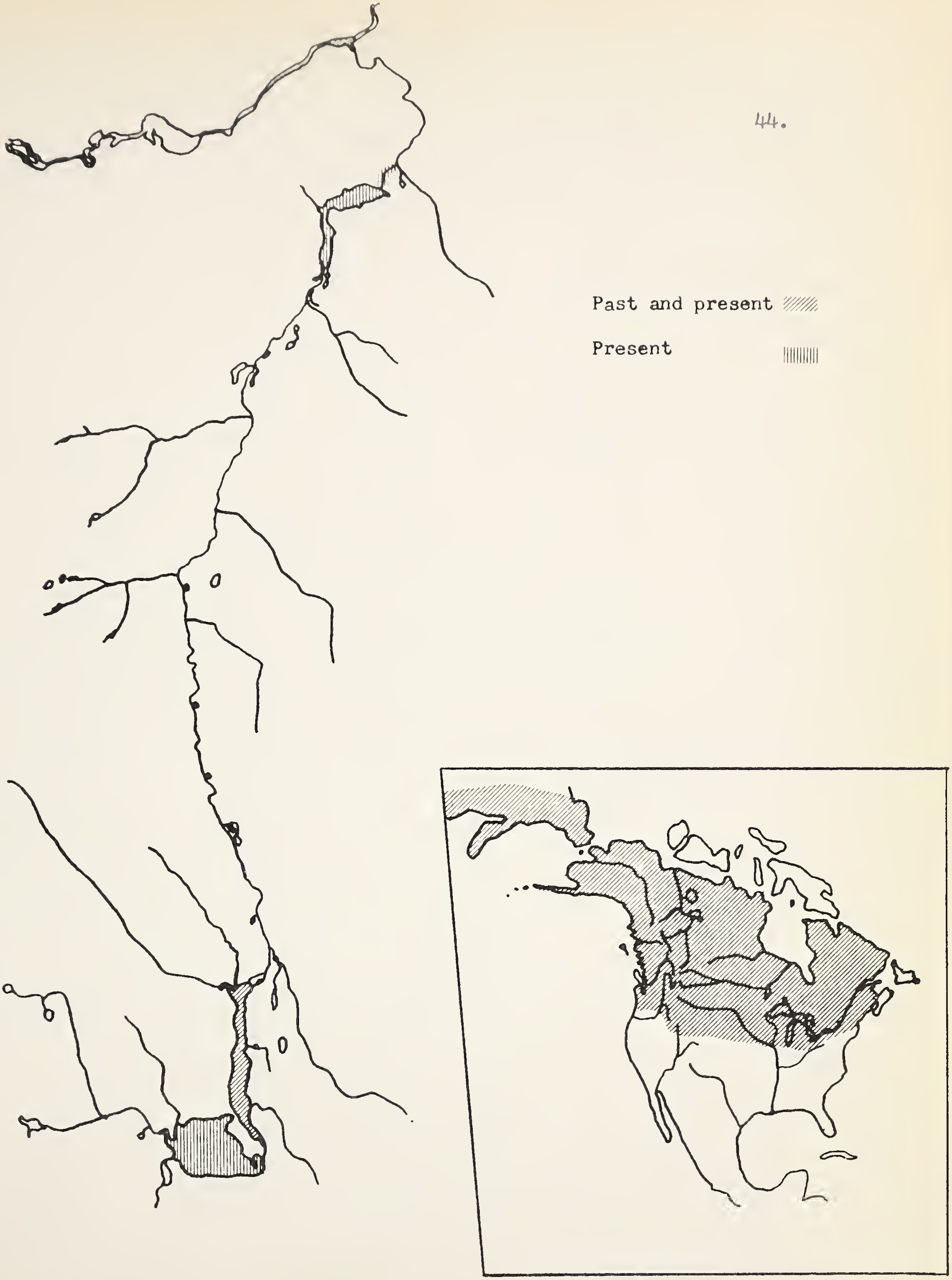


Fig. 21 Distribution of longnose sucker (Catostomus catostomus).

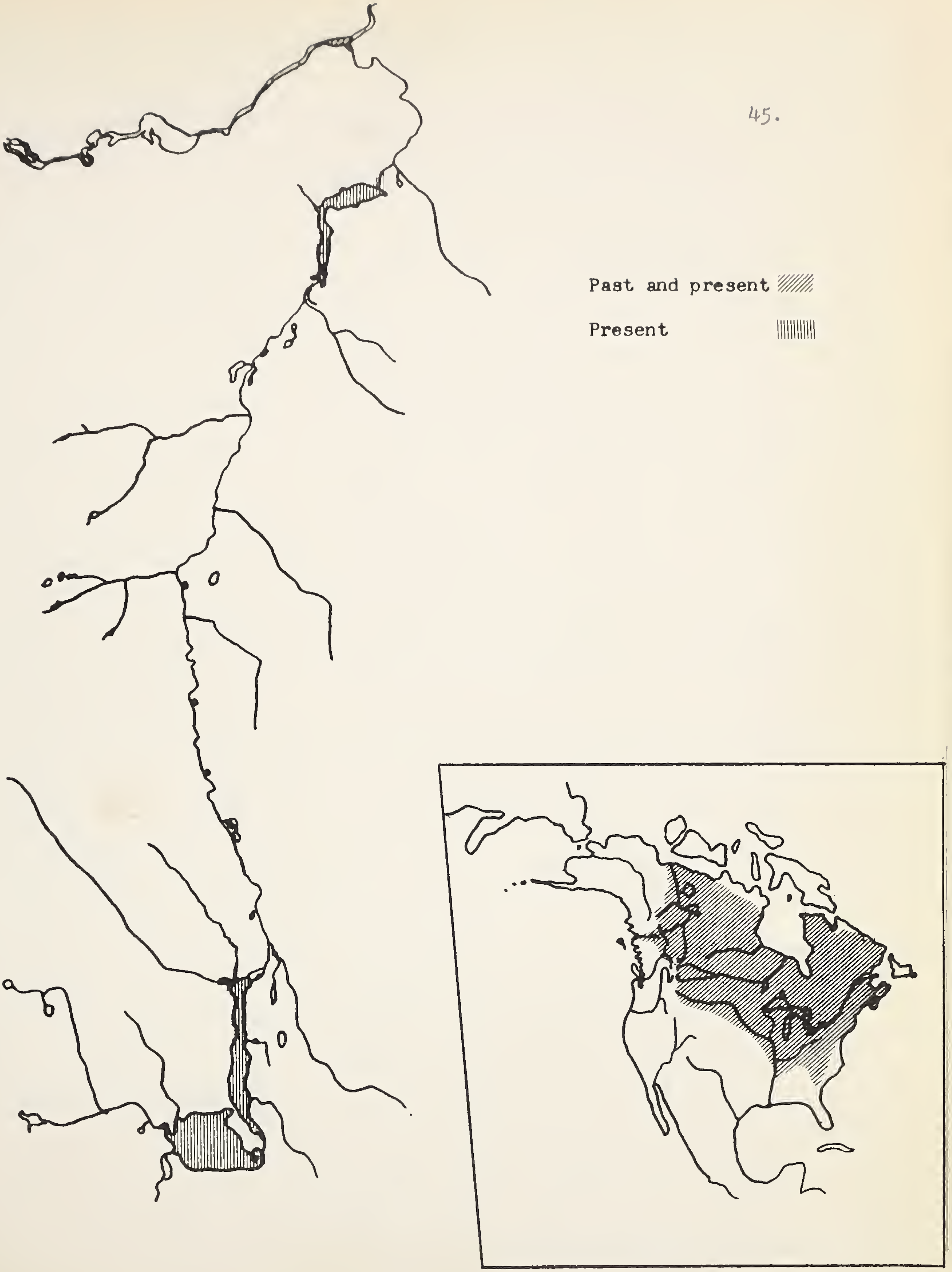


Fig. 22 Distribution of white sucker (Catostomus commersoni).

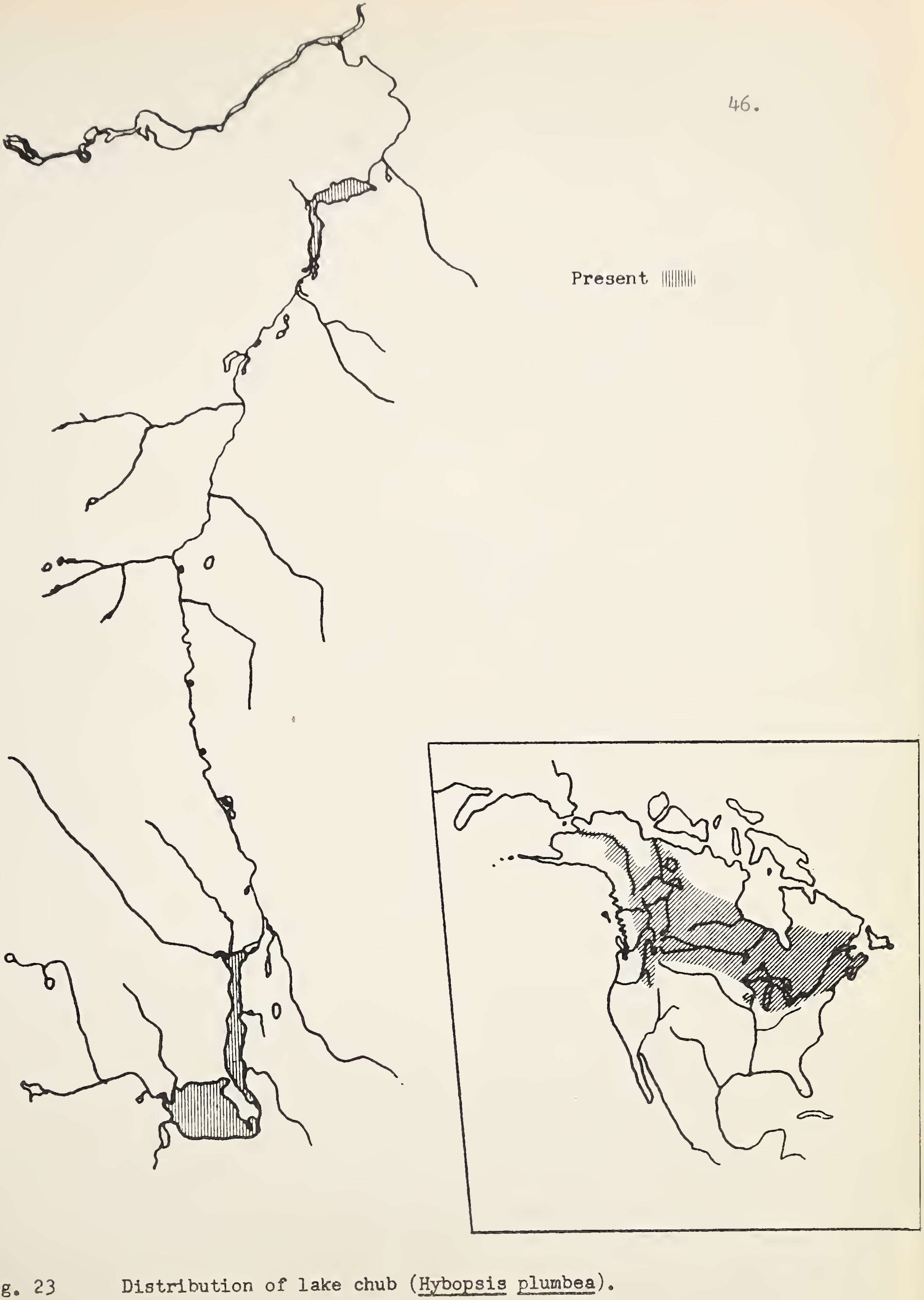


Fig. 23 Distribution of lake chub (Hybopsis plumbea).

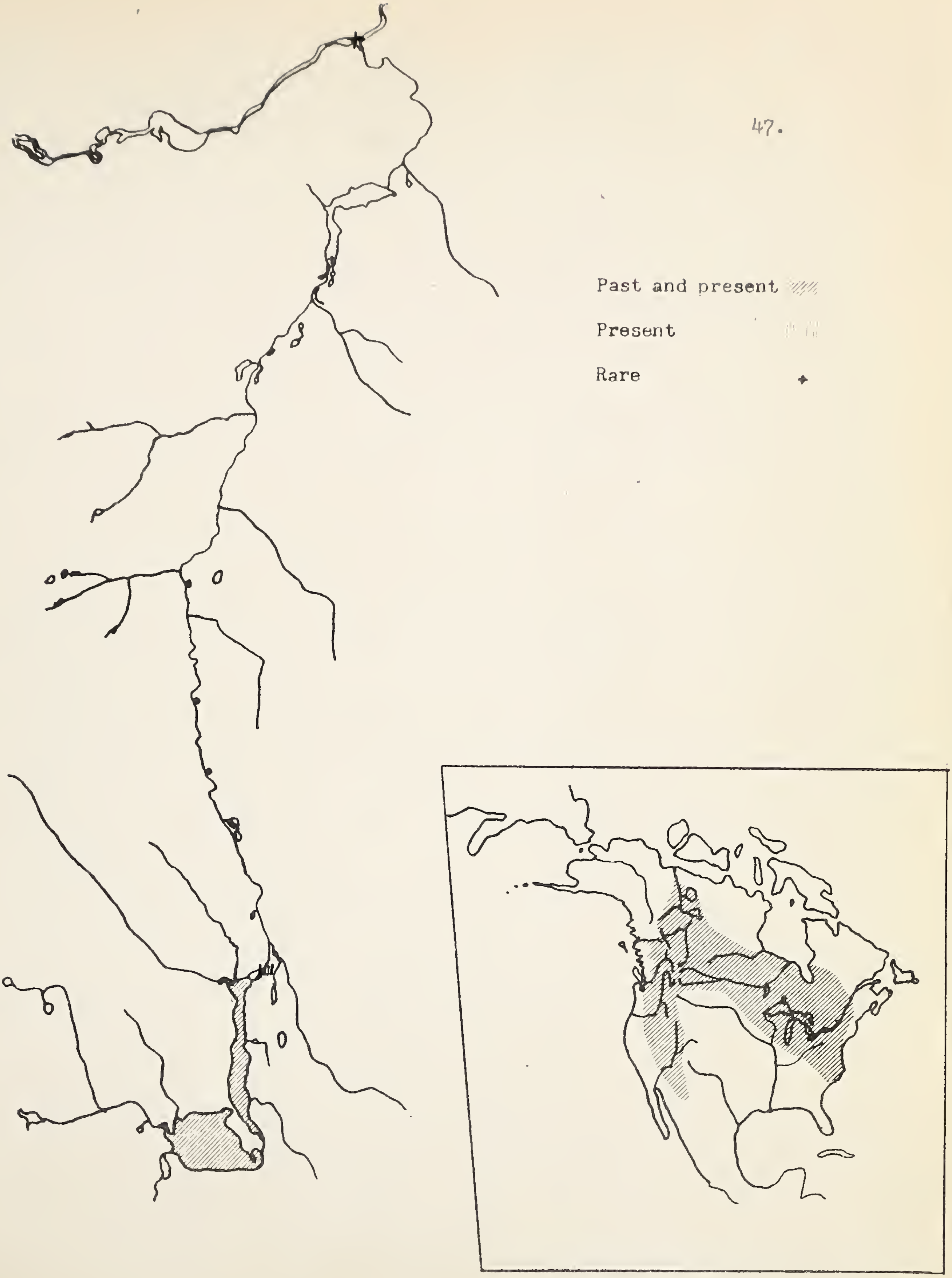


Fig. 24 Distribution of longnose dace (Rhinichthys cataractae).

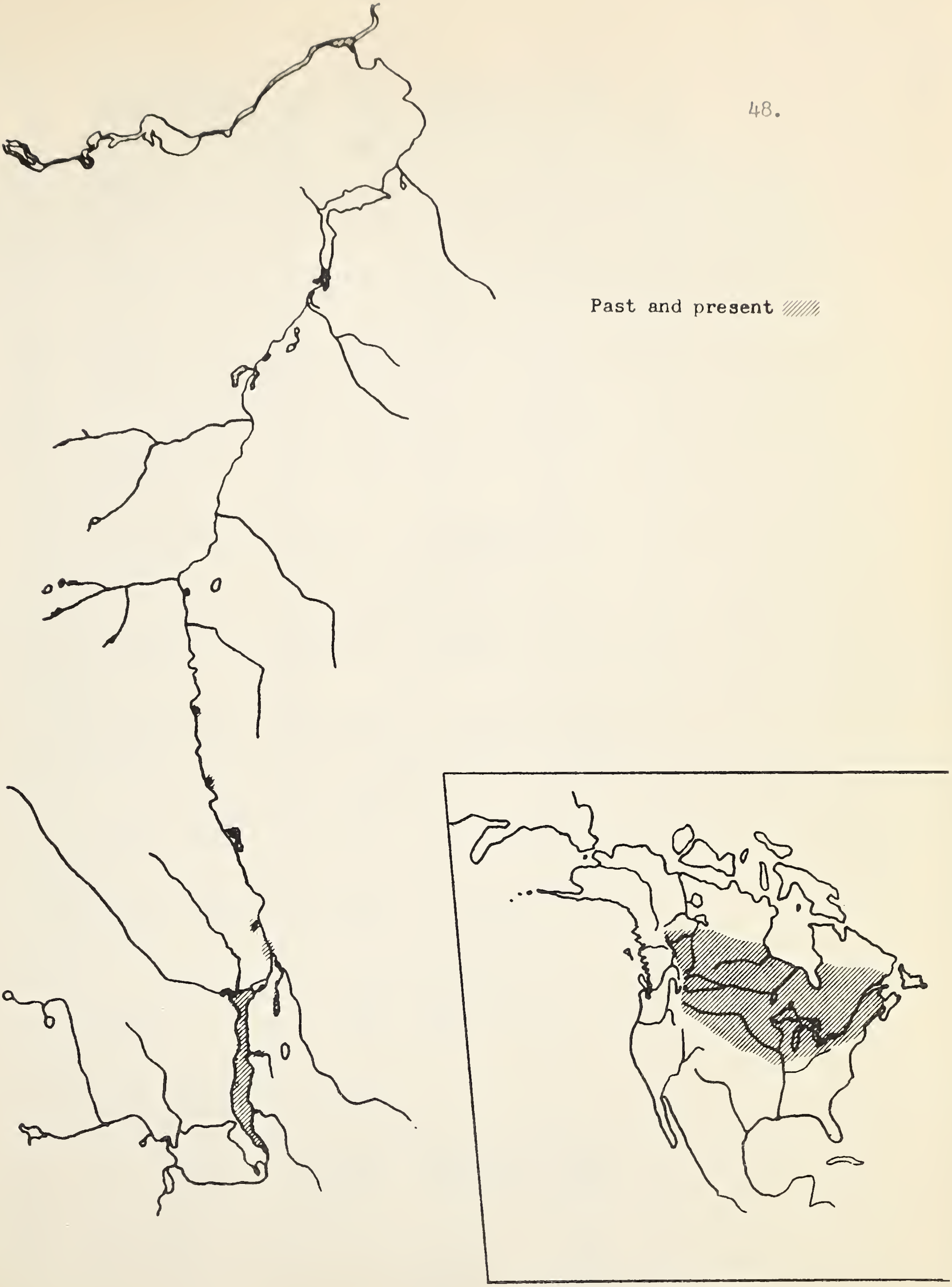


Fig. 25 Distribution of brook stickleback (Eucalia inconstans).

Table X. Percentage occurrence of different species gillnetted from 1936 to 1961. Pindicates presence noted by seining or non-quantitative gillnetting.

Reservoir	Year	Moun. white.	Long. suck.	White suck.	Brown trout	Rain. trout	Cut. trout	Dolly Varden	Brook trout	Lake chub	Long dace	Brook stick.	Total No.
Kananaskis	1938	76.5	2.0	-	-	-	7.0	14.5	-	-	-	-	55
	1947	53.5	-	3.5	21.5	11.0	-	7.0	0.5	-	-	-	28
	1961	40.0	3.5	40.0	16.0	-	-	0.5	-	P	P	P	157
Barrier	1947	47.5	-	-	-	9.0	23.5	20.0	-	-	-	-	156
	1948-49	P	-	-	-	P	P	P	-	-	-	-	-
	1960	68.0	6.0	18.5	7.5	-	-	-	-	-	-	-	289
	1961	48.0	24.0	17.5	7.5	2.0	0.5	-	-	0.5	P	-	1093
Lower Kananaskis	1936	-	97.5	-	-	-	1.0	1.5	-	-	P	-	207
	1947	-	3.0	-	-	51.5	1.0	44.5	-	-	-	P	101
	1954	-	0.5	74.5	-	1.0	13.5 hybrids	10.5	-	-	-	P	223
	1961	-	4.0	83.0	-	4.0		6.5	-	2	0.5	P	160
Upper Kananaskis	1936	-	-	-	-	100	-	-	-	-	P	-	16
	1947	-	-	-	-	100	-	-	-	-	P	-	27
	1961	-	66.0	1.5	-	16.5	-	-	-	14	2.5	-	242

Table XI. Percentage occurrence of different species seined in 1961.

Reservoir	Mountain Whitefish	Longnose sucker	White sucker	Brown trout	Lake chub	Longnose dace	Brook stickleback
Kananaskis	61	4	27	5	1	1	1
Barrier	40	22	36	0.9	1	0.1	-
Lower Kananaskis	-	2	47	-	7	40	4
Upper Kananaskis	-	45	21	-	27	7	-

species around the shoreline, it is unlikely that any bias has arisen because of different net locations in the past surveys. Bias resulting from different net meshes being used in the various surveys will be discussed where pertinent. Table Xl shows the species seined in the reservoirs in 1961 (these individuals are generally less than nine centimeters in fork length and thus too small to be caught in the gillnets).

A . General distribution by species

Mountain whitefish have ascended the Kananaskis River to Pocaterra Falls (Fig. 15). They are abundant in Kananaskis and Barrier reservoirs and throughout their range in the Kananaskis River. Specimens were not found in tributaries to the river (M.J.Paetz, per. comm., states that mountain whitefish in Alberta seldom ascend small tributaries). Adults occur in the tailrace of Pocaterra plant and were observed sporadically farther downstream. However, only fry and fingerlings were collected in the main river. Adults are probably less numerous in the river than formerly but their distribution has remained unchanged.

Mountain whitefish have probably crossed the Rocky Mountains into Bow River drainage through the Kickinghorse Pass from Columbia River refugia after retreat of the last Wisconsin glaciation. They are native to headwaters of the Bow River.

Dolly Varden have become greatly restricted in their native range since 1947 (Fig. 16). They were once common in Kananaskis Reservoir but are now rare. A. Guinn(per. comm.) reported them to be common in Barrier Reservoir and Kananaskis River and abundant

below Pocaterra Falls until 1949. They are now absent or rare from this area and remain as a population only in Lower Kananaskis Reservoir and Smith-Dorrien Creek.

Dolly Varden also probably crossed into the Bow River through the Kickinghorse Pass from Columbia River refugia. They are native to headwaters of the Bow River.

Brook trout have been stocked in several beaver ponds along the Kananaskis River (Fig. 17). Adults are common in Lusk, Upper and Lower Wasootch, and Powerline beaver ponds. Fry and fingerlings are present in Lusk Creek and Lusk Beaver Pond. Fry were observed in the beaver ponds stocked in 1961 (Table 1X) and were taken in Boundary Beaver Pond (Kan.R. dams of Table 1X). E.B.Cunningham (per. comm.) reports sighting one adult in the latter pond in 1959. Rawson (1948) reported them in Kananaskis Reservoir. They are now rare in the Kananaskis River, occasional individuals being found between Barrier and Kananaskis reservoirs.

Brown trout have invaded the lower Kananaskis system after their introduction into the Bow River via Carrot Creek (Fig.18). They were first taken in Barrier Reservoir by A. Guinn (per. comm.) around 1949 but were probably present by 1947 although undetected by Rawson (1948) and Nursall (1949). R.C.Thomas (per.comm.) angled adults in 1946 immediately below the present dam site. Fry and fingerlings are abundant in virtually all side-channels and sloughs of the Kananaskis River for 4.5 miles above Barrier Reservoir. Extensive collecting showed that brown trout young do not occur farther upstream than the area noted. Adults occur in the lower

reaches of Powerline Beaver Pond, throughout Tourist Beaver Pond, and may ascend the river past Ribbon Creek, but are probably rare. Whether any change has occurred in brown trout distribution over the past few years in the Kananaskis River is not known. They have greatly increased their numbers and range in the Bow River Reservoirs since their introduction and have spread at least 150 miles down the Bow River from Carrot Creek. They have not surmounted the falls at Banff but have been introduced above them.

The native cutthroat trout of the Kananaskis system (Fig.19) is virtually extinct (planted stocks originated from Bow drainage). Cutthroats were common, along with Dolly Varden, in the Kananaskis River and Evans-Thomas Creek in the 1930's and 1940's (per.comm. J.Naylor and E. Stenton) and in Barrier Reservoir up to 1949 (Nursall, 1949). In 1961 cutthroats were common in Lower Wasootch, Boundary, and Powerline beaver ponds, Ribbon Lake, Muskeg Creek, and Pocaterra plant tailrace, but were rare in Barrier Reservoir. The latter three populations are probably hybrids of various degrees. Lower Wasootch Beaver Pond may contain original Kananaskis cutthroat. The outlet of this pond seeps into dry gravel beds of Wasootch Creek but presumably is open to the river during spring run-off. It contains various age classes of cutthroat trout. Rawson (1948) stated that, "In Lower Kananaskis Lake, cutthroat appear to have been largely displaced by rainbow trout". He also reported a reduced number in Kananaskis Reservoir and other areas of the Bow River since 1938. They are now absent from both the above reservoirs.

Cutthroat trout probably came across the Kickinghorse Pass into Bow drainage from Columbia River refugia. They are native to headwaters of the Bow River.

Rainbow trout following their initial introduction into Upper Kananaskis Reservoir and later plantings rapidly spread and were abundant throughout the Kananaskis system in the 1940's (Fig. 20). Rawson (1948) notes that rainbows were established in Lower Kananaskis Lake by 1944 due to escapement from the Upper Reservoir. They are reported to ascend the various tributaries of Lower Kananaskis Reservoir. In 1961, rainbows were more numerous in Upper Kananaskis than in Lower Kananaskis Reservoir. They were rare in Kananaskis River and Barrier Reservoir and absent from Kananaskis Reservoir. Adults were once present in Grizzly Beaver Pond (per. comm. A. Guinn) but now are apparently absent. One adult was taken in Tourist Beaver Pond. Golden trout, a variety of Salmo gairdneri native to California, have been stocked in two high-altitude lakes, Golden and Three Isle.

Longnose suckers (Fig. 21), were observed in the Kananaskis River at the present site of Barrier Reservoir and in Smith-Dorrien Creek in the 1930's (per. comm. E. Stenton). They were undoubtedly introduced into Upper Kananaskis Reservoir where suckers were first reported present in 1952 (Files of Fish and Wildlife Branch, Edmonton). Rawson (1948) noted a decrease in their numbers in Lower Kananaskis Lake between 1936 and 1947 (as well as in several areas along the Bow River between 1938 and 1947). They have remained in low numbers in Lower Kananaskis Reservoir (Miller, 1954; Thomas, 1957; and present study). Longnose suckers occur in the Kananaskis River below Barrier Reservoir but not above it. Reports of suckers occurring in the Pocaterra plant tailrace could not be verified.

They may have entered the Bow River from either Columbia or Mississippian refugia or both and are native to the Bow River upstream from Banff.

White suckers (Fig. 22) were not reported in the Kananaskis system by Rawson (1948) or in Barrier Reservoir by Nursall(1949). Miller(1954) and Nursall(1960) reported them present in Lower Kananaskis and Barrier reservoirs respectively. They were numerous in both reservoirs at the time of their discovery. White suckers occur in the Kananaskis River below Barrier Reservoir and may have entered the latter prior to impoundment but were undoubtedly introduced into Lower Kananaskis Lake and Upper Kananaskis Reservoir. Young white suckers occur a short distance up Tourist Creek from Barrier Reservoir. They have increased in numbers in Kananaskis Reservoir since they were first reported present in 1947 (Rawson also noted an increase in their abundance in other Bow River areas between 1938 and 1947). White suckers probably entered the Bow River from Mississippian refugia. They are native in the Bow River but do not occur upstream from Banff.

Lake chub (Fig. 23) were first noted in the Kananaskis River system during the present study. They were found to be abundant in Lower and Upper Kananaskis reservoirs, rare in Kananaskis and Barrier reservoirs, and absent from all streams and beaver ponds. Lake chub were undoubtedly introduced from Bow River stock. They probably entered the Bow system from Mississippian refugia and are not native to the upper Bow River.

Longnose dace (Fig. 24) were reported in Upper Kananaskis Reservoir and Lower Kananaskis Lake in 1936 by Rawson. Only one specimen was taken in Barrier and Kananaskis Reservoir. They are absent in the Kananaskis River except immediately below Pocaterra Falls and plant. It is likely that they were introduced into the Kananaskis system. Longnose dace probably entered the Bow system from Mississippian refugia and occur in the Bow River above Banff but not in the headwaters.

Brook sticklebacks are abundant in many of the beaver ponds adjoining the Kananaskis River (but not in all) and in Lower Kananaskis Reservoir (Fig. 25). They occur throughout Grizzly Beaver Pond and even in swampy areas adjacent to the ponds but isolated from them except in the spring. Sticklebacks have probably entered Lower Kananaskis Lake either through introduction by man or through swampy areas from Pocaterra to Boulton Creek at high water. It seems unlikely that this species could have surmounted the falls and gorge at Pocaterra. They do occur in the Kananaskis River at the mouth of Pocaterra Creek where some individuals were observed to swim against a small current. They are not confined to, nor always found in, accessible areas where heavy vegetation occurs (as Winn,1960 suggests). Brook sticklebacks probably entered the Bow system from Mississippian refugia. They are native to the Bow River above Banff but not in the headwaters.

Rawson (1939a,b;1948) and J.C.Ward (per. comm.) report the following additional species from the upper Bow drainage. None has been recorded from the Kananaskis system. All distances are given from the mouth of the Kananaskis River.

Cisco (*Coregonus artedii*) have been successfully introduced into Minnewanka Reservoir (25 miles upstream). They have also been planted (1953) in Spray Reservoir (15 miles upstream). Lake whitefish (*Coregonus clupeaformis*) have been successfully introduced in Minnewanka Reservoir. Lake trout (*Salvelinus namaycush*) occur in Minnewanka Reservoir and in Ghost Reservoir (15 miles downstream). Northern pike (*Esox lucius*) occur in Glenmore Reservoir (45 miles downstream). Flathead minnow (*Pimephales promelas*) occur in Bighill Creek (30 miles downstream). Blacknose dace (*Rhinichthys atronasus*) were reported in Lake Minnewanka by Rawson but their presence requires further confirmation. Mosquitofish (*Gambusia affinis*) were successfully stocked near Banff in hot springs (36 miles upstream). Trout-perch (*Percopsis omiscomaycus*) are found in Jumpingpound Creek (29 miles downstream). Burbot (*Lota lota*) occur in the Bow River near Banff and in Ghost Reservoir.

B. Distribution within the reservoir and streams

In Barrier Reservoir all species of fish tend to remain within 100 feet of the shoreline and near the bottom. Little horizontal zonation or vertical movement between daylight and night was noticed. A small proportion of the whitefish and trout were caught in the middle area of the reservoir. Along steep banks young whitefish tended to stay close to the shoreline and bottom. They were rarely farther out from shore than 20 feet and were common near the bottom up to depths of 47 feet. In shallow areas they may extend farther from shore. Whitefish, by seven months of age, are distributed around the shoreline. Godfrey(1955) reports very few adult mountain whitefish at depths below 50 feet in deep Skeena River (British Columbia)

lakes with most being above the 10 foot stratum. Table X11 shows the percentage distribution of fish in two areas of Barrier Reservoir throughout the summer. The increased catch of young mountain whitefish and decreased catch of young suckers as the season progressed is attributed to gillnet selectivity. Young mountain whitefish were growing into the critical capture size (10 to 13 cm) of the 1 inch gillnet while the suckers were growing past it. Table X11 shows that longnose suckers (10 to 13 cm) outnumber similar sized white suckers. This accounts for the difference between the 1960 and 1961 gillnet catches in Table X. In 1960 small meshed gillnets were not used. Table X1 shows that very small white suckers (on the average less than 10 cm) outnumber the longnose suckers. The species ratio in various year classes varies considerably. All individual seine hauls and gillnet catches were consistent with the above observation.

In Lower Kananaskis Reservoir suckers and minnows are numerous in shallow shore areas. White suckers are common in open waters up to28 feet in depth. Only Dolly Varden and rainbow trout were caught in the deepest areas of the reservoir (135 feet). They were large (46 to 62 cm) mature fish.

In Upper Kananaskis Reservoir suckers and minnows occur in dense schools in shallow shore areas. Only rainbow trout were caught in the open water, i.e., more than 200 feet from shore. Trout below the depth of 65 feet are rare and other species are apparently absent. Cartwright (1961) gives evidence that in oligotrophic lakes rainbow trout occur mainly in shallow shore areas. Nets (1,1.5, and 2 inch mesh) set between 128 and 148 feet for 22.5

Table XII. Percentage occurrence of gillnetted fishes in two areas of Barrier Reservoir. Figures are from monofilament gillnet catches only. 1 = May, June and early July, 2 = late July and 3 = late August.

	CAMP						BAY						CORNER						BAY					
Fork length (cm)	Mount. wh.			W.sucker			L.sucker			B. trout			Mount. wh.			W.sucker			L.sucker			B.trout		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
10 - 13	9	27	46	4	3	3	32	28	4	2	2	-	6	57	58	-	-	-	-	-	-	11	6	1
14 - 17	-	1	1	-	-	-	-	1	-	1	1	6	3	-	1	-	-	-	-	-	-	3	-	-
18 - 21	-	-	3	-	-	-	3	1	-	-	-	6	1	2	4	-	-	-	-	-	-	-	-	-
22 - 25	1	-	7	-	-	-	-	2	-	-	1	2	2	2	10	-	-	1	-	-	4	2	-	-
26 - 29	-	-	1	-	-	-	3	2	-	-	-	2	-	1	4	-	-	-	-	-	1	3	-	1
30 - 33	-	1	3	5	5	1	17	2	-	-	-	2	2	-	2	-	1	1	31	3	8	6	3	-
34 - 37	-	-	-	14	10	4	1	6	1	-	1	-	14	1	1	2	5	1	6	9	1	-	-	-
38 - 41	-	-	-	6	5	8	1	-	-	-	-	-	3	-	-	5	8	1	-	-	-	-	-	-
42 -	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-

hours were empty.

In monthly poisonings of a side-channel of the Kananaskis River 0.75 miles south of Barrier Reservoir, mountain whitefish were found to outnumber brown trout 10 to 1. The population completely ~~Complete replacement took~~ reëstablished itself monthly ~~place at least once a month~~ in this 0.5 mile long channel. In some of the slow moving sloughs the two species are in equal numbers but brown trout generally occur farther upstream than whitefish. In the Kananaskis River whitefish fry are most numerous in muddish-bottomed side-channels with side cover. Rainbow trout occurred only sporadically in the river.

Several areas were checked extensively without any fish being found. Marmot Creek, Twin Creek, the Kananaskis River above Twin Falls, side-channels of the Upper Kananaskis River, and the outlet of Lyautey Lake were poisoned without any sign of fish resulting. The latter creek seemed especially suitable for fish. Boulton and Pocaterra creeks were also checked above the Kananaskis road without any results from poisoning. However, one adult trout was observed in the latter. No fish occur in Limestone Beaver Pond and several other smaller ponds. It also seems likely that Upper Kananaskis Lake was originally devoid of fish. The observations of J. Naylor and E. Stenton in the 1920's and early 1930's support this view. The absence of longnose dace from the river and streams (their common habitat) makes it seem unlikely that this species ascended the Kananaskis River into the lake.

On week-ends between 1300 and 1800 hours during the summer months approximately 30% of the cars passing Barrier Reservoir northbound contained people who fished. Of these, approximately 50% caught fish.

In Barrier Reservoir, mountain whitefish formed 85% of the catch with the rest divided between brown and rainbow trout. Three to four boats were generally the maximum observed on the reservoir at any one time. Most people fished from shore.

Fishermen generally caught rainbow trout and Dolly Vardens in equal numbers in Lower Kananaskis Reservoir. Shore fishermen caught large numbers of white suckers. Tributaries were closed to fishing but poaching of rainbow trout was known to occur. Five to ten boats were generally the maximum number on the reservoir at any one time. Shore fishermen equalled in numbers those fishing in boats.

Upper Kananaskis Reservoir is the largest producer of rainbow trout. It was not uncommon for a car to have 13 or more rainbow trout from this reservoir. Fishing remained good throughout the season. Trout are reported to be smaller but more numerous than in the past.

Catches in the river were poor, except in power plant tailraces. Rainbow trout were caught by road crews immediately above Pocaterra Falls.

Beaver ponds attracted only a small percentage of fishermen. Upper Wasootch Pond was frequented by some who caught

adult brook trout. Tourist Beaver Pond and the spillway pool below Barrier dam were fished for brown trout.

Only the occasional person fished in Ribbon Lake for cutthroat trout.

Angling was reported to have been heavy during construction of the reservoirs and during World War II in the vicinity of Barrier Reservoir.

Dolly Varden are probably the most easily caught and brown trout the hardest to catch of the Kananaskis game fish.

X. BIOLOGY OF THE FISHES

A knowledge of the behavior, food, growth, spawning time and area of the Kananaskis fish will provide a basis for establishing causes for the change in their abundance and distribution. All ages of fish are given from time of fertilization (approximated spawning time). Equations for length-weight relationships were derived from eye-fitted regression lines plotted on double logarithmic graph paper and solved by the two-point method with simultaneous equations. Dispersion of points was very small, except where noted, thereby allowing some conclusions to be made regarding significant differences between populations. The gonadosomatic index (GSI) was calculated from the formula:

$$\frac{\text{weight of gonad}}{\text{weight of fish}} \times 100$$

A. Mountain whitefish

Schooling in mountain whitefish became evident at the age of 7 months (from November) in the river and reservoirs.

Fry showed no tendency to hide but reacted to disturbances by swimming away. Schools tended to occupy small bays of the river. They often were displaced by fluctuations in the river level, but this was probably of no harmful consequence. Over 95% of the whitefish had moved down the Kananaskis River and into Barrier Reservoir by the age of 1 year 8 months (July), thereby leaving only one year class (0^+) abundant in the river above the reservoir. McHugh (1936) reported a downstream movement at a similar age in the Okanagan Valley of British Columbia.

Whitefish are adapted to feed on many different types of food. Nursall (1949) reported a shift in the whitefish diet from allochthonous river organisms to autochthonous bottom forms (mainly chironomids) in Barrier Reservoir between 1947 and 1948 due to changes in abundance of these invertebrates. In 1961 chironomids were dominant in the diet of whitefish in Kananaskis and Barrier reservoirs. Back-swimmers, caddis larvae, oligochaetes, crustaceans, clams, and snails were rare in their stomachs. River whitefish fed primarily on stonefly and mayfly larvae. Stonefly larvae, chironomid larvae, mosquito pupae, and both terrestrial and aquatic beetles were rare in stomach samples. Whitefish in the pool below Barrier spillway fed heavily on black fly larvae (Simuliidae) in August. McHugh (1937) and Godfrey(1955) reported that whitefish feed heavily on planktonic and benthic insects. Cartwright (1961) found them to eat viable rainbow trout eggs in the Lardeau River, British Columbia.

Fig. 26 gives the growth rate of immature whitefish in Barrier Reservoir. Most growth occurs between June and September.

Fig. 27 shows that the 1961 growth rate of whitefish in both Kananaskis and Barrier reservoirs has increased since 1947 and that the former population had a faster growth rate than the latter in both years. The growth rate of the Kananaskis whitefish is comparable to that of whitefish in the Skeena River Lakes of British Columbia (Godfrey, 1955). The first circulus on the scales was formed when fish were 2.6 cm long (average of 7 months old) with the first annulus forming at approximately 12 months of age. Table Xlll shows that the Kananaskis Reservoir whitefish are heavier per unit length than those in Barrier. There was little overlap in the plotted points which suggests that the difference is significant.

In Kananaskis Reservoir (August) all immature whitefish had a GSI of less that 1%. Mature 2 to 6 year old males varied from 7.1 to 12.5% and 3 to 4 year old females varied from 5.0 to 8.5%. In Barrier Reservoir (August) 2 to 6 year old males varied from 7 to 19% and 3 to 7 year old females varied from 8 to 14 %. In June, maturing males and females averaged 1 and 2% respectively. The greatest increase in gonad weight thus occurred in July and August. Brown(1952) reported a GSI of 21.8% for one large female from the Yellowstone River, Montana.

In Kananaskis Reservoir all but one female were mature when 3 years (yr) 9 months (mo). None were mature at 2 yr 9 mo. Approximately 50% of the male 2 yr 9 mo and all the 3 yr 9 mo fish were mature. In Barrier Reservoir most 3 yr 11 mo females were ripe while all males of the same age and about 30% of the 2 yr 11 mo group were ripe. Barrier Reservoir fish thus became

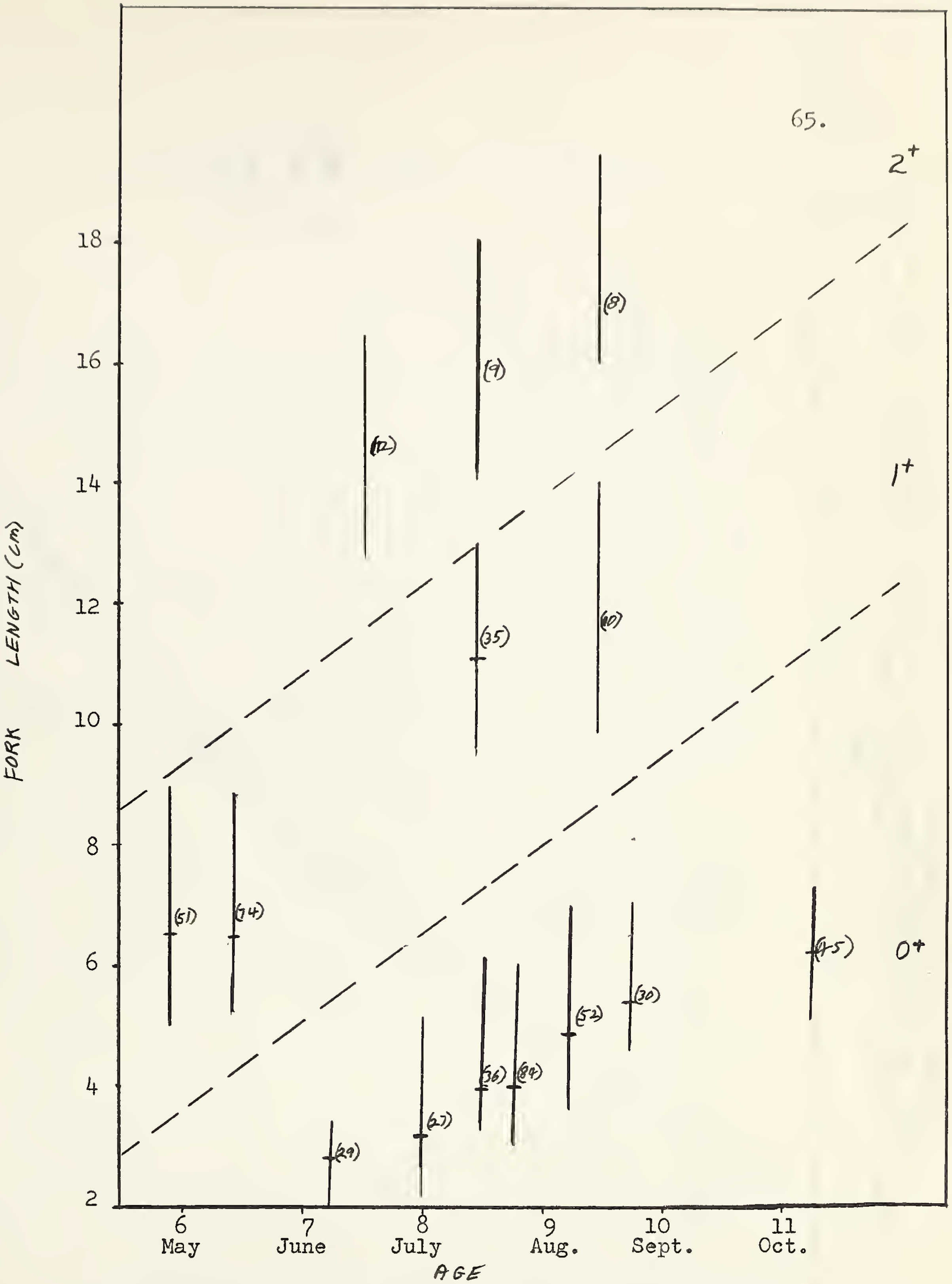


Fig. 26: Summer growth of immature mountain whitefish in Barrier Reservoir. Several collections have been grouped for each range. Mean length given for some. Age in months from November. Sample size in parenthesis.

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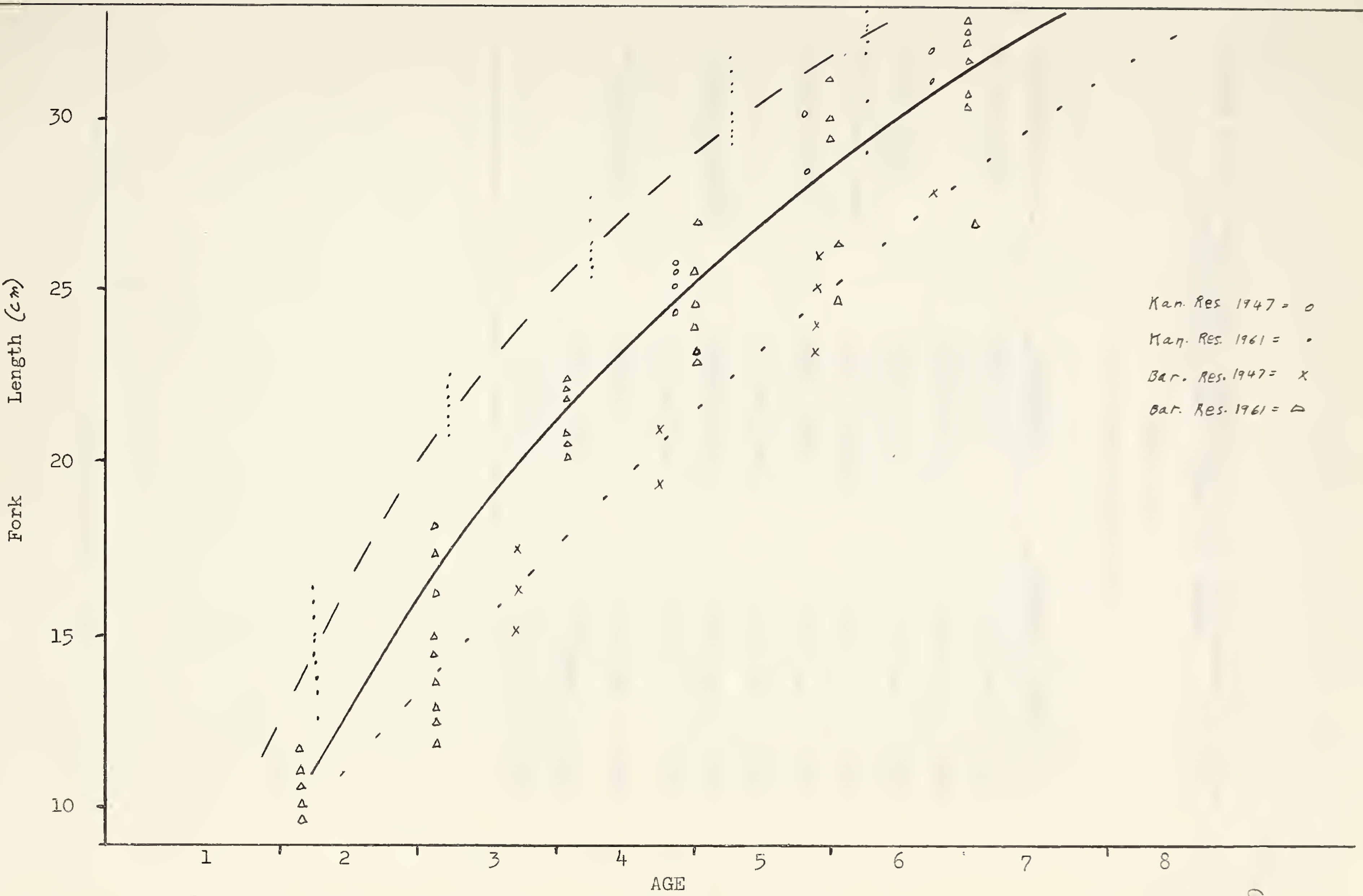

Fig. 27. Growth of mountain whitefish in Kananaskis and Barrier reservoirs. (Kan. Res. 1961 = - - -; Kan. Res. 1947, Barrier Res. 1961 = ________; Barrier Res. 1947. = ...). Rawsons 1947 data modified.

Table XIII. Length-weight relationships of some Kananaskis fish. From equation LogW = nlogL - b, where

W = weight in g

L = fork length in cm

Species	Location	Equation (LogW=)
M. Whitefish	Kan. Res.	3.039 logL - 1.939
	Barrier Res.	3.029 logL - 2.008
Brown trout	Barrier Res.	2.734 logL - 1.620
Cutthroat trout	Lower Wasootch	2.545 logL - 1.445
Rainbow trout	Kan. River	2.817 logL - 1.597
	U. Kan. Res.	3.171 logL - 2.091
Longnose sucker	Barrier Res.	3.184 logL - 2.105
	U. Kan. Res.	2.968 logL - 1.907
White sucker	Kan. Res.	2.959 logL - 1.769
	Barrier Res.	3.107 logL - 2.010
	L. Kan. Res.	3.224 logL - 2.164

mature at a smaller size than those in Kananaskis Reservoir but on the average they were the same age. Brown (1952) states that most Montana whitefish mature when 2^+, but a few do so when 1^+.

All mature males developed tuberculated scales (epidermal nipples)in October, giving the fish a rough appearance.

From the distribution of fry it is evident that considerable river spawning occurs. However, no adults were observed in October in the river. The presence of running and spent females along the southern shore of the east arm of Barrier Reservoir suggests that beach spawning also occurs. Hatching probably occurs shortly before spring drawdown. Brown (1952) observed whitefish spawning in gravel and rubble areas of streams (41 - 32°F) in the last part of October and the first part of November. He found hatching to occur in March.

B. Dolly Varden

Immature Dolly Varden (four age classes) in Smith-Dorrien Creek were noted to hide under rocks. They were not observed to school.

Rawson (1939a) reported Dolly Varden in Kananaskis Reservoir to feed on suckers and aquatic insects. Nursall (1949) noted that between 1947 and 1949 in Barrier Reservoir there was an increase in the use of chironomids and river organisms and a corresponding decrease in the use of terrestrial organisms. Between 1947 and 1949, of the various fish examined, only Dolly Vardens of the latter year were found to have fish remains in their stomachs. Rawson(1937) reported Dolly Varden in Lower Kananaskis Lake to feed on suckers,

stoneflies, and mayflies. Miller (1954) stated that this species fed primarily on leeches and amphipods, and to a lesser extent, on young trout and suckers. In 1961 chironomids ~~dominated the~~ were the most abundant organism in the stomach contents. Nilsson (1955) found that chars turned to open waters to feed on plankton in Swedish lakes when the bottom food reached its lowest abundance. Carl et al (1959) report that Dolly Varden feed on fish, bottom organisms and sometimes fish eggs.

Table XIV shows the lengths of immature age groups of Dolly Varden in Smith-Dorrien Creek.

Table XIV. Growth of Dolly Varden in Smith-Dorrien Creek.

Fork length in cm. Number of specimens in parenthesis.

9 mo	1 yr 9 mo	2 yr 9 mo	3 yr 9 mo
3.1-4.2 (7)	6.9 - 9.5 (6)	10.0 - 12.5 (4)	16.0 (1)

Difficulty in aging chars prohibited analysis of adult fish. Thomas (per. comm.) found Dolly Varden up to 72 cm long and 4530g in weight in Lower Kananaskis Lake, 1954.

Dolly Varden do not reach maturity in the Kananaskis system until they are quite large. Miller (1954) reported the majority mature at 5^+, or about 50 cm in length. All below 38.7 cm were immature. Nine specimens ranging from 33.7 cm to 46.0 cm were all immature in 1961. Only one female (49.5 cm), caught on June 10 with a GSI of 2.1%, was maturing. No young were taken in the reservoir and no evidence of runs occurring up Boulton or Smith-Dorrien creeks was obtained although such migrations are reported by anglers. The young taken in Smith-Dorrien Creek may belong to a resident creek population. Carl et al. (1959) gives the spawning time as occurring between mid-August and early November.

Fig. 28 shows the young of brown trout, rainbow trout, Dolly Varden, and brook trout.

C. Brook trout

Fry of brook trout hide under objects but not as readily as Dolly Varden and brown trout. They were not observed in compact schools. Vincent (1960) reports wild populations of brook trout fry to hide when disturbed while domestic stocks do not.

In Lusk and Lower Wasootch beaver ponds brook trout fed on back-swimmers, beetles, and other aquatic insects. In Powerline Beaver Ponds bits of wood and gastropod shells were in their stomachs.

Growth of brook trout appears to be good in all beaver ponds, except Lower Wasootch. All fish captured were moderately plump.

Mature males (3 in number) and females (3) were taken in Lusk Beaver Ponds in early September and varied from 21.3 to 25.0cm in length. All were 2 yr 11 mo old. Immature individuals, 0^+ and 1^+, were present. These must have been descendants of stream invaders since the only stocking was in 1959. In Lower Wasootch Beaver Pond mature males (2) and females (2) varied from 14.0 to 17.2 cm in length on August 15. In Powerline Beaver Pond mature males (2) and one female varied from 24.5 to 27.0 cm in length on August 22. All were 2 yr 10 mo and survivors of the 1959 stocking. Brook trout fry were observed in Upper Wasootch and Powerline beaver ponds. They are survivors of the 1961 planting. Fry averaging 6.5 cm in length were taken in Boundary Beaver Pond on

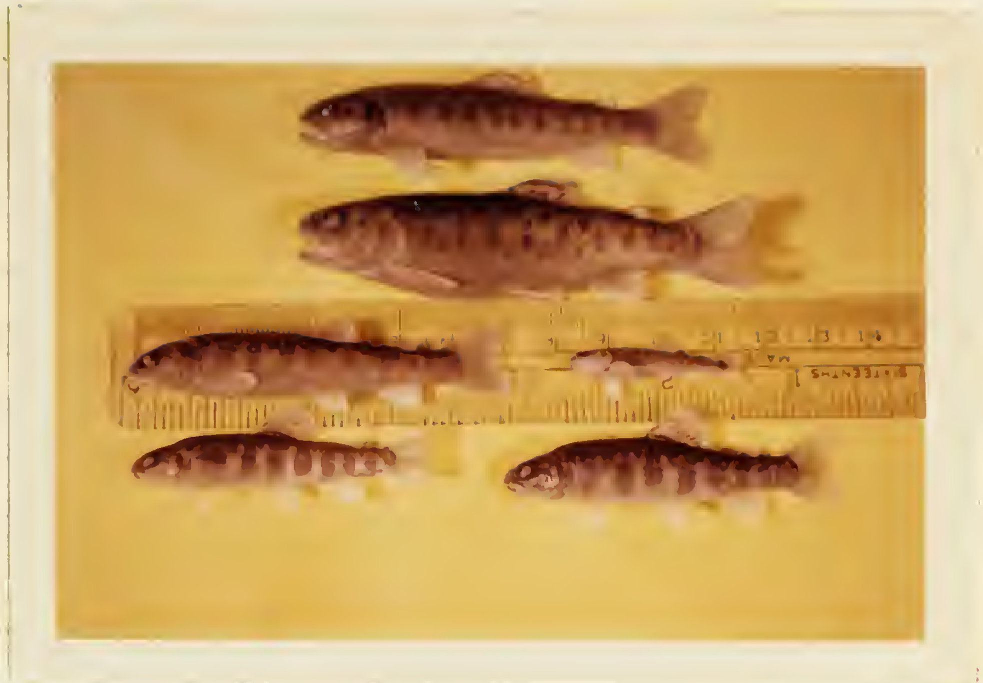

Fig. 28. Young of brown trout, rainbow trout, Dolly Varden, and brook trout. Species are in order, with brown trout at the top.

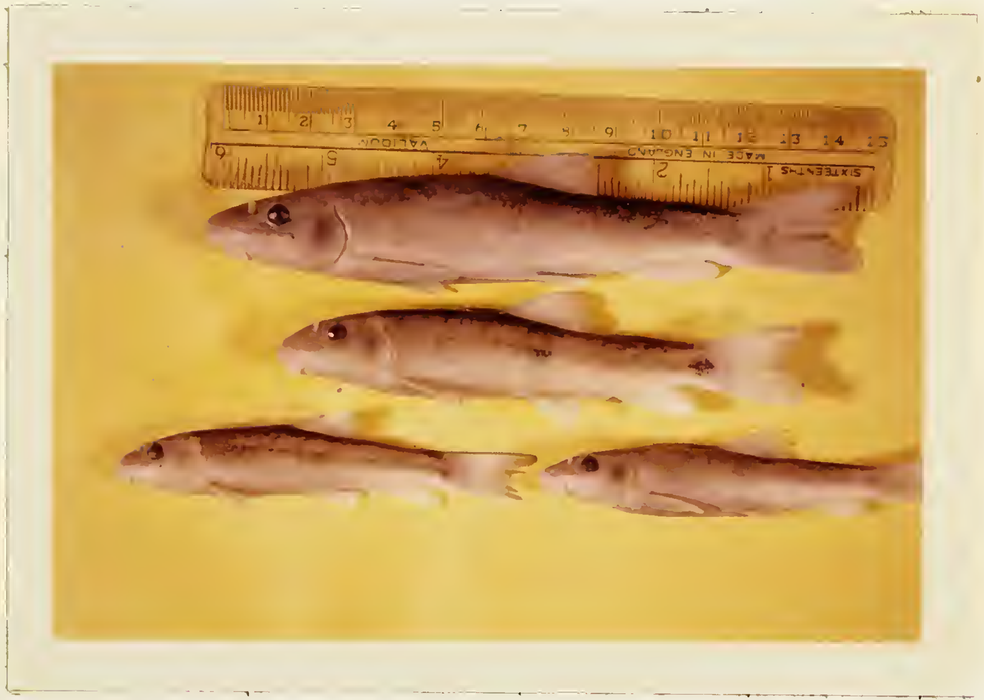

Fig. 29. Immature longnose and white suckers. Longnose sucker at top with three white suckers underneath.

August 2. They are offspring from a previously established population. Limited reproduction evidently occurs in Lusk and Boundary beaver ponds and probably will occur in the Wasootch ponds. Cutthroat trout spawning already occurs in Lower Wasootch, and a small inlet, suitable for limited spawning, drains into Upper Wasootch. Brook trout also spawn in Lusk Creek about 0.75 miles up from the Kananaskis River where 9 mo old (2.3 cm) and 1 yr 9 mo old (6.5 cm) individuals were collected. McFadden (1961) has noted mature yearling females as small as 4.1 inches. He reports spawning in September with emergence of fry in February and March.

D. Brown trout

Brown trout do not school and are highly territorial in their behavior (Allen, 1951; Stuart, 1953). They were seldom seen as they invariably hid under objects, rocks or logs, when disturbed. Lindroth (1955) and Kalleberg (1958) have observed much the same. These authors have reported that fry actively defend their territories from the young of other species.

In Kananaskis Reservoir brown trout fed on aquatic stoneflies, mayflies, and chironomids in 1961. Nursall (1960) gave their diet in Barrier Reservoir as consisting mainly of terrestrial insects, stream fauna such as caddis larvae, stoneflies and mayflies, and some chironomids and small fish. In July 1961, the trout in the Barrier spillway pool fed heavily on dance fly adults (Empididae). Fry and fingerlings inhabiting sloughs at the head of Barrier Reservoir fed mainly on Gammarus and oligochaetes. Fry in the river had aquatic insects in their stomachs. Neill (1938) reported brown

trout to feed on a wide range of organisms but Ellis et al. (1957) report that feeding may be quite selective.

Fig. 30 shows the summer growth of immature brown trout in the Barrier Reservoir area. Individuals from the outlets of Tourist and Powerline beaver ponds often show exceptionally rapid growth rates and they are omitted from the graph. Fig. 31 shows that the growth rate of brown trout in Kananaskis Reservoir exceeds that of Barrier Reservoir while both exceed the growth rate Rawson(1948) obtained for fish of Gap Lake and Ghost Reservoir. The length-weight relationship for brown trout in Kananskis Reservoir (Table XIII) did not significantly differ from that in Barrier Reservoir.

It is evident from the distribution and abundance of fry that considerable spawning occurs in the Kananaskis River for 4.5 miles above Barrier Reservoir. Some spawning also occurs in Lusk Creek, the Kananaskis River below Barrier Reservoir, and in Tourist Creek and Beaver Pond. It was not established at what age the brown trout mature. All individuals up to 32.5 cm (age 4^+) were immature. Stuart (1953) reported spawning to occur from October to February in Britain while Needham et al. (1945) noted spawning from late October to early November in California with hatching in early April.

E. Cutthroat trout

The general behavior of cutthroat and rainbow trout are probably similar (see below). Miller (1957a) has noted cutthroats to be confined to small home ranges in Alberta streams.

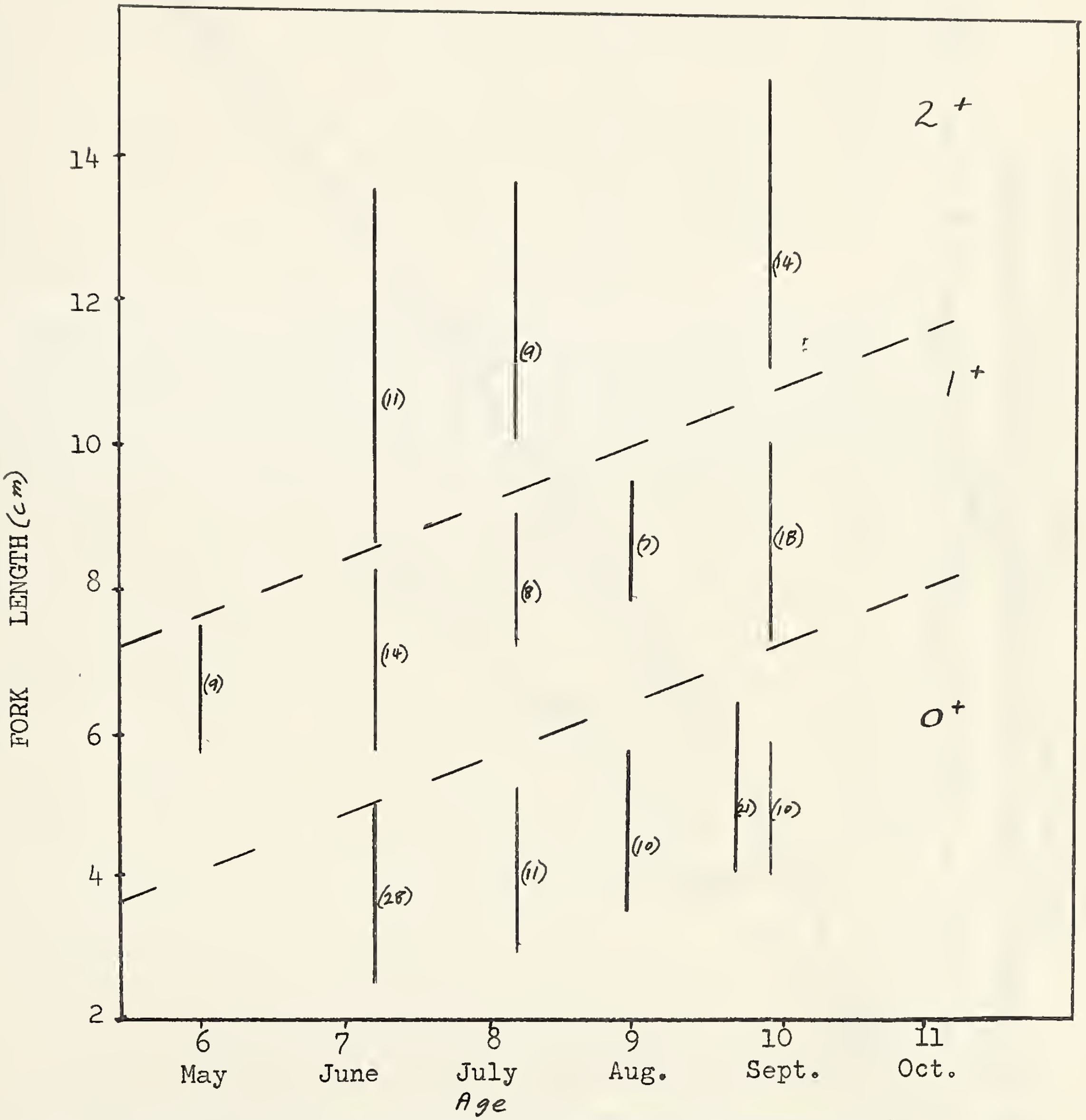

Fig. 30: Summer growth of immature brown trout in Barrier Reservoir and Kananaskis River. Several collections have been grouped for each range. Age in months from November. *Sample size in papenthesis.*

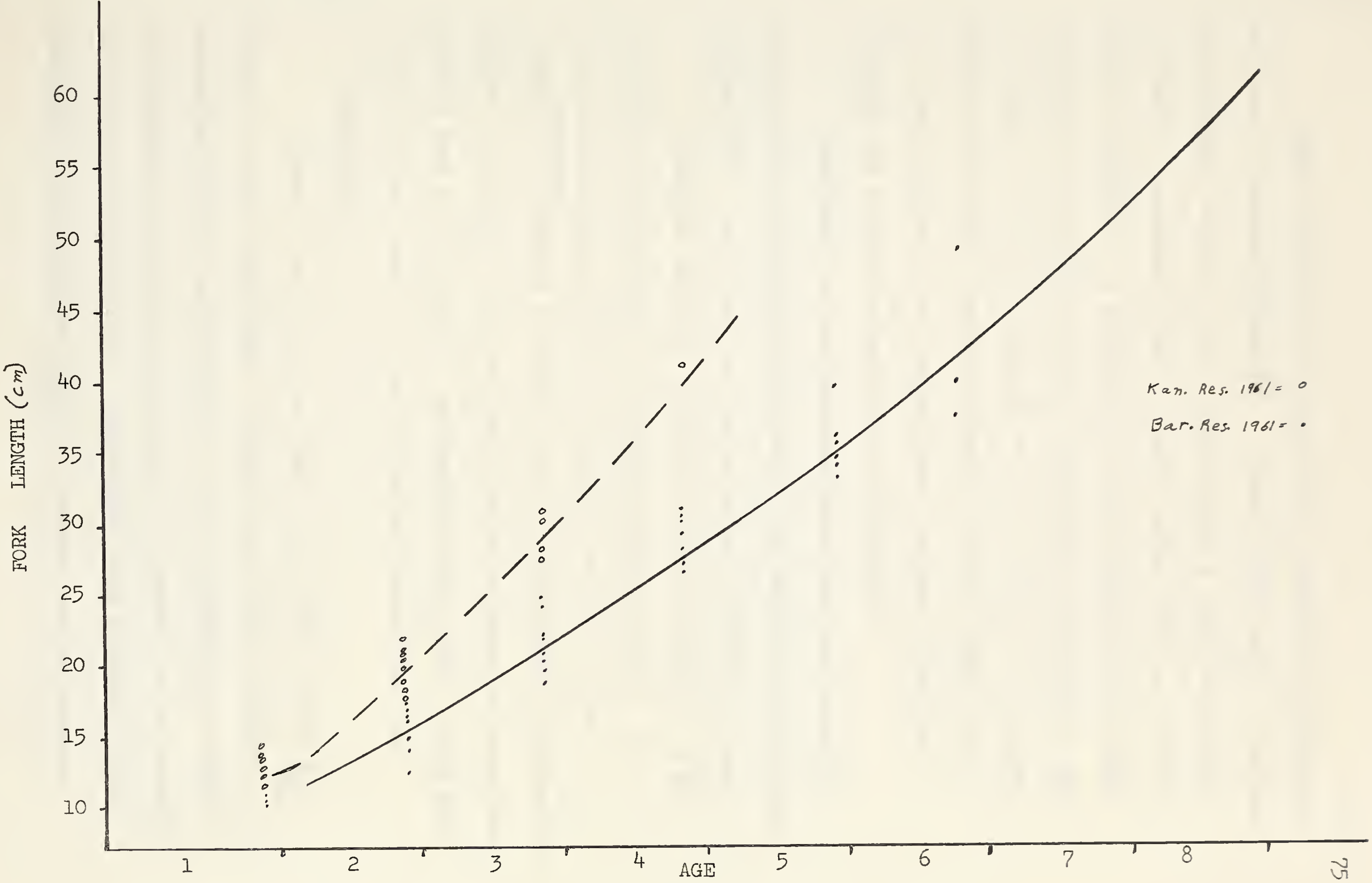

Fig. 31: Growth of brown trout in Kananaskis and Barrier reservoirs.
(Kan.Res. 1961 = ---; Barrier Res. 1961 = ———).

Rawson (1939a) found cutthroat trout feeding on grasshoppers and ants in Kananaskis Reservoir. Nursall(1949) noted an increase in chironomid larvae and river organisms and a large decrease in terrestrial organisms in their stomachs between 1947 and 1949 for Barrier Reservoir. In Powerline and Lower Wasootch beaver ponds cutthroats were feeding on ants, back-swimmers, and beetles. One individual in the latter pond had two 10 cm trout in its pharynx. McMynn et al. (1953) reported cutthroats to have a faster growth rate than rainbows in the Campbell River drainage of British Columbia due to their consumption of sticklebacks.

Individuals in Lower Wasootch Beaver Pond were generally exceptionally thin although there was a wide variation in condition (Table XIII). Individuals in other areas were moderately plump.

In Barrier Reservoir on May 19 a 29.0 cm female had a GSI of 9.0% and would probably have spawned within one month. In Lower Wasootch Beaver Pond all individuals over 17.6 cm had spawned that summer. The presence of various age classes shows that reproduction occurs in this pond. All individuals netted in Powerline Beaver Pond, varying from 21.0 to 29.5 cm, and Boundary Beaver Pond, varying from 17.8 to 21.2 cm, were 2 yr 5 mo old and had spawned that year.

F. Rainbow trout

Rainbow trout fry did not tend to hide under objects as readily as brown trout young. Stringer et al. (1955) described aggressive behavior and territorial defence in yearlings of this non-schooling species, but this behavior is probably not as strongly developed as in brown trout. Miller(1954a) found rainbows in Lower Kananaskis Lake feeding on amphipods, leeches, and chironomids.

Thomas (1957) noted *Gammarus* to be the chief food with *Daphnia* and snails also present in the stomach contents. Rawson (1937) reported 13 mo old rainbows in Upper Kananaskis Reservoir to be feeding on *Daphnia*, *Gammarus*, copepods, and a few dipterous adults. In 1947 Rawson noted them to be feeding on *Daphnia*, copepods, chironomid larvae, and to a small degree, mayflies and caddis larvae. Predation on fish is rare or absent. Suckers and minnows in the shallow shore waters occupy an area uninhabited by the trout. In the Kananaskis River rainbows fed on mayflies and stoneflies in 1961.

Fig. 32 shows the growth in Lower and Upper Kananaskis reservoirs while Table XV gives the length range for various age classes of rainbows in the Kananaskis River above Pocaterra Falls. The length-weight relationship for the latter two populations is shown in Table X111. Rawson(1948) reported trout up to 7.5 inches long, 13 mo old, in Upper Kananaskis Reservoir in 1936 and 22 inches long, 4 yr 1 mo, in 1939, with growth slowing down in later populations. Miller (1954a) suggested the faster growth in Lower Kananaskis Lake was due to the presence of amphipods, which were all but absent in Upper Kananaskis Reservoir.

Table XV. Growth of rainbow trout in Kananaskis River above Pocaterra Falls. Fork length in cm. Number of specimens in parenthesis.

2 mo	1 yr 2 mo	2 yr 2 mo	3 yr 2 mo
2.3- 3.0(8)	7.0 - 10.7(13)	12.8 - 18.0(16)	21(1)

In Barrier Reservoir on May 14a female 30.5 cm long had a GSI of 14.5% and was about to spawn.

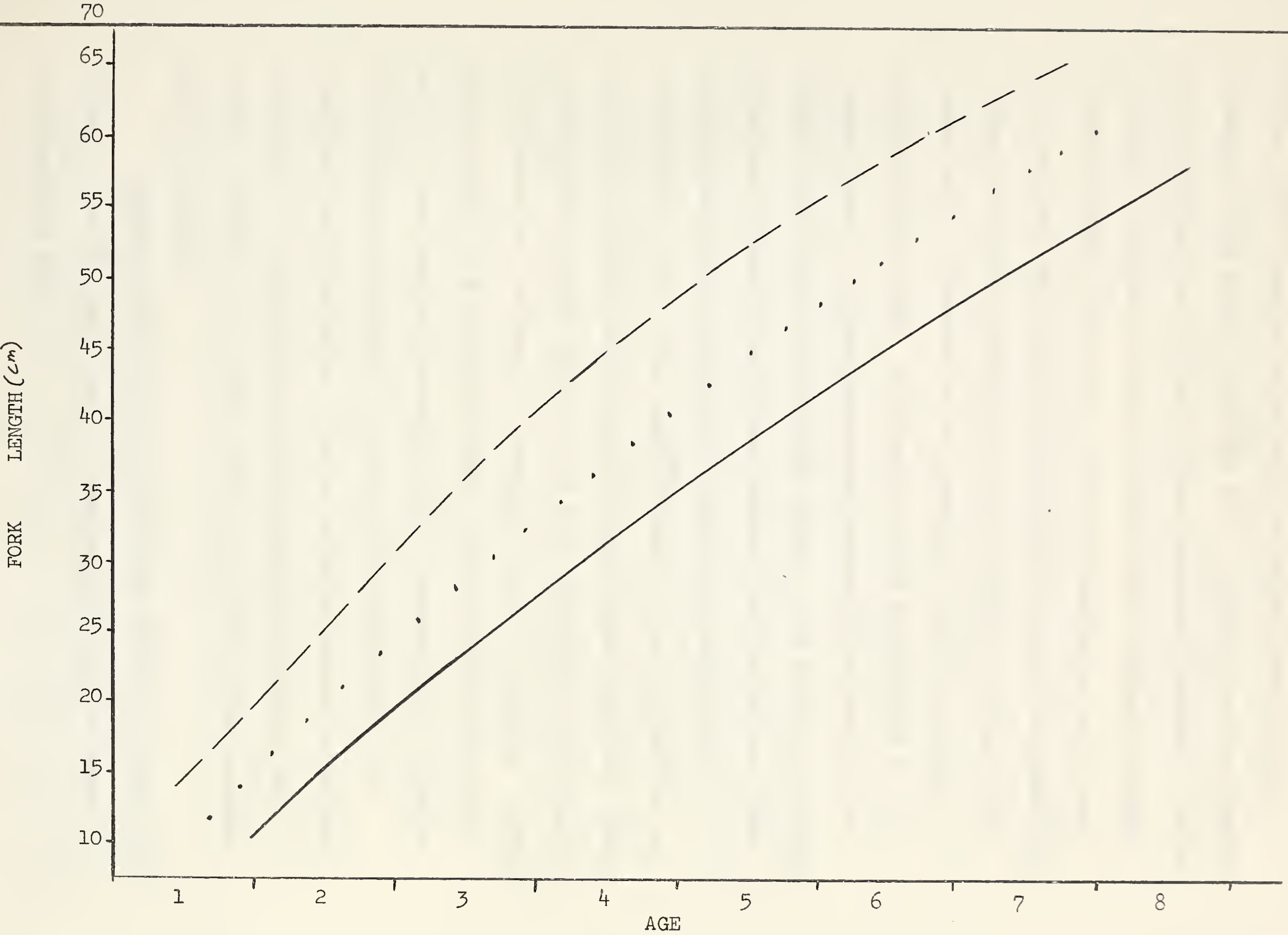

Fig. 32: Growth of rainbow trout in Lower and Upper Kananaskis reservoirs.

(L. Kan. Lake. 1947 = ———; L. Kan. Lake. 1954. = - - -; U. Kan.Res.1954=...).
after Rawson (1948) and Miller (1954a).

Miller (1954) reported the majority of rainbow trout in Lower Kananaskis Lake mature at the age of 5^+. Maturity, on the average, was reached one year earlier in Upper Kananaskis Reservoir. Miller also noted spawning to occur below Twin Falls (between Upper and Lower Kananaskis reservoirs) in May with hatching in early July. It is unlikely that significant spawning occurs here now since the volume of water and spawning area were reduced in 1942 and 1955 respectively. Fishermen report spawning in Smith-Dorrien and Boulton creeks in May. No evidence of this was obtained in the present study. In Upper Kananaskis Reservoir two ripe females were taken on July 8 and were 45 and 60 cm long. The majority of netted trout were between 20 and 30 cm. Rawson (1948) and Miller (1954) reported little or no spawning. However, the presence of 1^+ individuals, eight of them caught and between 9.4 and 12.5 cm long in this reservoir indicates that successful spawning does occur now. Heavy silting and turbulent waters in the Upper Kananaskis River below the falls makes this tributary an unsuitable site for spawning. Cordone et al. (1961), in a literature review, note the lethal effects of silt on trout eggs and Cartwright (1961) reports similar findings for Kootenay Lake rainbows. Other creeks examined enter the reservoir over high falls. Since no suitable spawning inlets were observed, it is concluded that beach spawning in alluvial fans occurs. Hartman et al. (1962) state that mortality after spawning may be very high.

Northcote (per. comm.) and Cartwright (1961) have shown that rainbow trout fry cannot hold in currents when the water temperature is below 13 or 14°C.

As previously mentioned, pure strains of cutthroat and rainbow trout are probably absent. A hybrid (Salmo clarki x gairdneri) makes up most of the reservoir populations.

G. Longnose sucker

Longnose suckers school in all the reservoirs. Schools vary in size from 10 to 100 or more individuals. Immature suckers occur in shallow shore areas throughout the summer, but rarely in the spring and fall. They show no tendency to seek cover, but react to disturbances rather like mountain whitefish fry, i.e., by swimming away in schools.

In Barrier Reservoir the main source of food for longnose suckers was chironomid larvae and detritus. Rawson(1937) reported chironomid larvae, caddis larvae, and a few amphipods in the stomach contents. MacPhee (1960) reports young suckers, soon after hatching, to be plankton feeders, consuming diatoms, protozoans, rotifers, and cladocerans, and only later changing to bottom feeding.

Table XIII shows that suckers in Upper Kananaskis Reservoir are somewhat lighter per unit length than those of the Barrier population. Table XVI shows the growth of immature longnose suckers in the upper reservoir. It is likely that most of the suckers go through their first winter without scales. Brown et al. (1954) postulated the same for the Yellowstone Lake, Montana, population. Growth analysis of the adults was not made.

Table XVI. Growth of immature longnose suckers in Upper Kananaskis Reservoir. Fork length in cm. Number of specimens in parenthesis.

1 mo	1 yr 1 mo	2 yr 1 mo	3 yr 1 mo	4 yr 1 mo
1.4 - 2.0 (90)	3.5 - 4.6 (100)	6.0 - 8.1 (100)	8.6 - 9.5 (100)	12.0 - 14.0 (30)

Rawson(1937) noted that individuals in Lower Kananaskis Lake did not exceed 30 cm. In the present survey adults between 30.0 and 35.5 cm were caught. No evidence of a stunted population was noted.

In Barrier Reservoir running males and females were first taken on June 6 with the first spent individuals caught on June 26. Geen(1958) records spawning in longnose suckers in British Columbia as occurring from April to late May, shortly after the melting of ice cover. Harris (1962) reported spawning to occur in Great Slave Lake in May and early June but Brown et al. (1954) found it to occur in late June in Yellowstone Lake. Spawning is reported generally to occur in inlets (Geen, 1958) but beach spawning is likely common in the Kananskis system.

The GSI, prior to spawning, was found to be as high as 15%. Cartwright (1959) reported a high of 12.4% in British Columbia.

Tubercles were always present on the anal and ventral lobe of the caudal fin of mature males. They were most pronounced during spawning. A pinkish band was present on the sides of mature and large immature individuals.

Ligula commonly made up 20% of the body weight in 2^+, 3^+, and 4^+ individuals in Upper Kananaskis Reservoir. It was less abundant in Lower Kananaskis Reservoir and rare in the others.

H. White suckers

Immature white suckers generally schooled with longnose suckers. The food of the two suckers appears to be similar.

In Barrier Reservoir the first male with running milt was noticed on May 13 while general running occurred in males on June 6 and in females on June 19. Spawned specimens were first taken June 26 with some spawning as late as July 20. In Lower Kananaskis Reservoir only running males were taken on June 10. Females were ripe but not running. The GSI for males varied from 6.8 to 7.5% and for females from 10.0 to 16.1%. By July 7 all had completed spawning. However, some mature individuals never did spawn. The GSI ranged from 2 to 3% in the spawned fish. Immature fish which would spawn in the following year ranged from 1 to 2% in GSI. By August 8 the GSI ranged from 3.1 to 9.2% in all maturing individuals. Cartwright (1959) gave the GSI for white suckers as 10.4% in British Columbia. Miller (1954) observed white suckers spawning in shallow shore areas of Lower Kananaskis Lake at the end of June. In 1961, white suckers reached spawning size at 31 cm (5^+) in all the reservoirs. Geen (1958) reports that in British Columbia white suckers spawn in inlets and occasionally in outlets shortly after the ice cover goes out in lakes. They generally spawn when 5 to 8 years old with high survival after spawning. In land-locked lakes of Alberta white suckers obviously must beach spawn and likely only do so in the Kananaskis system with high survival after spawning.

Young sucker fry (0^+) were first collected in Kananaskis Reservoir July 3, Lower Kananaskis Reservoir July 6, Barrier Reservoir July 10, and Upper Kananaskis Reservoir July 22. These

dates are not intended to represent the first appearance of hatched suckers but only when they were first observed. Carl et al.(1959) report that hatching occurs in one week from fertilization.

Tubercles are always present on the anal and ventral caudal fins of adult males. Ligula infections were common only in Lower and Upper Kananaskis reservoirs.

I. Lake chub

Lake chub commonly occurred in schools with suckers and longnose dace. They fed on Diaptomus and other crustaceans, chironomids, aquatic insects, and algae.

The largest individuals were slightly over 13 cm (5^+). In Upper Kananaskis Reservoir in July many females (3^+) were maturing. Running was noted on August 8 and 9 in Lower and Upper Kananaskis reservoirs respectively. The GSI was generally less than 8% but occasionally exceeded 15%. Geen (1955) reported spawning to occur from June to early August and gave a hatching time of two weeks.

Mature males have a distinct reddish patch behind the pectoral fins, tubercles on the head and pectoral fin, and wide pectoral fin bases. In ripe females, the reddish patch is faint or absent. No tubercles are present.

In Upper Kananaskis Reservoir some specimens were taken which resembled *Hybopsis plumbea* x *Rhinichthys cataractae.*

J. Longnose dace

Longnose dace generally schooled with suckers and lake chub. Reed(1959) reported the species to be insectivorous,

feeding mainly on simuliids, chironomids, and ephemerids.

Ripe females were taken in Lower and Upper Kananaskis reservoirs as late as August 8 and 9 respectively. Reed(1959) reports the maximum age of males as 4^+ (96 mm) and of females as 5^+ (118 mm). The largest individual taken in 1961 was a 115 mm female (5^+) from Upper Kananaskis Reservoir.

Many of the dace were infected with Ligula, throughout their range.

K. Brook stickleback

Winn(1960) reports brook sticklebacks to feed on insects and crustaceans. They are reported to live until 3 years old. Largest individuals were 4.4, 5.7, and 5.0 cm taken in Tourist and Eau Claire beaver ponds, and Lower Kananaskis Reservoir respectively.

Ripe females were taken on June 7 and July 12 from Tourist and Pocaterra beaver ponds respectively. Ripe females were also taken July 12 in Lower Kananaskis Reservoir. On August 2 they had already spawned in Eau Claire Beaver Pond. Winn(1960) reports that brook sticklebacks mature when one year old and spawn from April to July.

Many populations were infected with Ligula. Exceptionally heavy infections occurred in Pocaterra Beaver Pond where the larva commonly formed up to 35% of the body weight of an individual fish.

XI. DISCUSSION

A. Fishes

Mountain whitefish show no sign of being unfavorably affected by hydro-electric development or by other species of fish, Indeed their growth rate has actually increased since 1947. The length of their river life is determined by behavioral reactions to the fluctuating waters and location in the river. Schools inhabiting the main river channel are displaced into Barrier Reservoir at a relatively earlier age than previously. Schools inhabiting protected side-channels would be prevented from being displaced before their normal downstream movement when 1^+. Their lack of a hiding reaction to disturbances does not bring them into competition with brown trout. An early maturity and relatively long life have also aided in their success.

Whereas mountain whitefish remain successful in their native range, Dolly Vardens have become rare. Several factors have led to their decrease:

a) displacement by brown trout where their ranges overlapped (see discussion of brown trout for mechanism).

b) competition with white suckers in Lower Kananaskis Reservoir. Since Rawson(1948) reported an increase in Dolly Varden from 1936 to 1947 associated with a decrease in longnose suckers it is suggested that competition with suckers does have a detrimental effect on this species.

c) relative old age and large size before maturity. Catchable size is reached well before maturity. Although fishing pressure is low, productivity in the area is also low.

d) naturally high vulnerability to anglers.

e) changes in spawning area. Since 1942 and 1955 the Kananaskis River below Twin Falls and Boulton Creek have respectively been lost as significant spawning areas. However, Smith-Dorrien Creek has been added and probably is the main spawning stream.

Dolly Varden have probably reached relatively stable numbers but improvement and protection of spawning grounds would increase their numbers.

Brook trout have been displaced by brown trout from the Kananaskis Reservoir. The population density of brown trout is not sufficiently high to displace them from Lusk Creek nor will it ever likely be high enough to displace them from Powerline Beaver Pond. Newman(1956) has shown that brook and rainbow trout can live together compatibly and tend to behave as one species complex. There is no suggestion that the two species have adversely affected one another. Hallum(1959) states that brook trout occur in cool water in Ontario. They may then be able to survive (if planted)in the Kananaskis River above the range of brown trout. Beaver ponds appear to support the best populations of brook trout but regular planting is needed where reproduction fails to occur.

Brown trout fry and fingerlings are well adapted to fluctuating rivers. They have a fixed territory-holding habit

during rising water but seek open water during a decreasing water velocity, thereby avoiding capture in shore pools (Lindroth, 1955). Campbell (1957) has noted an increase in growth rate during flooding and suggests that an increased number of displaced oligochaetes would cause this. Wiggins (1950) reports similar observations. Among young salmonids, brown trout dominate in competing for space (amensalism), Adults may be more passive. They generally select the most favorable position in rivers and are successful in aggressively defending their territory from intruders (Kalleberg,1958). Introduced brown trout have been noted to displace native trout throughout North American inland waters (Fenderson, 1954, for Maine; R.J.Naverre, per. comm., for New Mexico; and Northcote, 1960, for western North America). Wiggins (1950) and K.Radway Allen (per. comm.) cite some instances to the contrary. Worthington (1941) notes that brown trout have held their own in Great Britain against introduced rainbow trout. Brown trout are difficult to catch by the angler (Andriano, 1960; Fenderson, 1954; Miller, 1957a; Northcote, 1960; and Wiggins, 1950). Gard (1961) has shown that beaver dams are not impassable to trout. Brown trout have invaded into and dispersed throughout Tourist Beaver Pond, and may do so in Powerline Beaver Pond.

The native Kananaskis cutthroat trout is extinct, except possibly in Lower Wasootch Beaver Pond. It is likely that cutthroat trout hybridized with introduced rainbow trout. Their observed decrease in Lower Kananaskis Lake from 1936 to 1947 corresponds with an increase in rainbows and concurrent hybridization. Darlington (1957 - page 84) states that the presence of suckers

reduces the numbers of trout. Brown trout also likely had a detrimental effect on cutthroats in the lower Kananaskis system. Any cutthroat strain in Upper Kananaskis Reservoir trout is likely from introduced hybrids. It is unlikely that there were any survivors of the 1914 cutthroat planting. Miller (1953) has suggested that feeder streams do not act as nurseries for main streams but have resident populations of their own. The reduction or elimination of Dolly Varden and cutthroat trout in tributaries of the Kananaskis River suggests that feeder streams may even be somewhat dependent on the main streams or that they have been "fished out". Cutthroat trout are apparently doing well in beaver ponds.

Rainbow trout have decreased in numbers since 1947 because of:

a) displacement by brown trout where ranges overlapped.

b) cooling in the upper reaches of the Kananaskis River below the critical holding temperature of the fry, 13 to 14°C, since 1955.

c) competition with white suckers.

d) decreased spawning area in Lower Kananaskis Reservoir. Beach spawning in Lower Kananaskis Reservoir is likely insignificant but appears to be the main source of reproduction in Upper Kananaskis Reservoir. Improvement and protection of the spawning grounds in Lower Kananaskis Reservoir would increase the numbers of trout.

The steady decrease in longnose suckers between 1936 and 1947 as substantiated by gillnet catches for taking trout eggs

between 1942 and 1947 in Lower Kananaskis Lake has been attributed by Miller (1954a) to the destruction of the major spawning inlet, the Kananaskis River below Twin Falls. This hypothesis fails to explain the decrease in longnose suckers, approximately concurrent with an increase in white suckers, in Lac des Arcs and Gap Lake which have had stable physical conditions. Longnose suckers are also capable of beach spawning, as in Barrier and Upper Kananaskis reservoirs. Longnose suckers were apparently never abundant in Kananaskis and Horseshoe (five miles downstream from the former) reservoirs, but were very abundant in Ghost Reservoir. Since the change from longnose to white suckers was not concurrent in Lower Kananaskis Lake, the succession could not have been due to competition from this species, although competition does likely occur since different ratios in numbers of various age classes in Barrier Reservoir exists. Increases in trout and char have not previously been noted to affect suckers. Rawson et al. (1950) ~~failed to note~~ did not observe an improvement in the rainbow trout fishery of Pyramid Lake, Alberta, after heavy netting of longnose suckers for five years. A large population of suckers, however, was still present, as well as predaceous lake trout. If, as Rawson(1937) reports, longnose suckers over 30 cm long were not present or were rare in Lower Kananaskis Lake, then either they matured at a much smaller size than they do now or something happened to the larger sizes prior to 1936. An over-abundant number of young suckers in Upper Kananaskis Reservoir is suggestive of an expanding population. They have probably reached stable numbers in the other reservoirs. A common answer probably does not exist for the observed sucker

changes in the various reservoirs and much more information is needed to arrive at a suitable explanation.

White suckers following their introduction into the various reservoirs greatly increased in numbers after 1947 to become one of the dominant species,except in Upper Kananaskis Reservoir , as they did in Lac des Arcs and Gap Lake between 1938 and 1947. They have been abundant in Ghost Reservoir but rare in Horseshoe Reservoir since at least 1938. Their unusually late spawning in the reservoirs, especially in Barrier, may be a result of natural selection. Eggs laid prior to stable water levels may have become destroyed. White suckers have probably reached stable numbers in the various reservoirs and are abundant in all but Upper Kananaskis Reservoir.

Paloumpis (1958) has reported numerous minnows to withstand drought and flooding conditions in Iowa. The absence of lake chub and longnose dace from the Kananaskis River and its tributaries is suggestive that some condition other than water fluctuation is unfavourable to them. There is little doubt that lake chub were recently introduced into the system. The absence of any "relict" populations of longnose dace outside the reservoirs is suggestive that it was also introduced, but prior to 1936. The two minnows are likely in competition with each other and, especially the longnose dace, with the suckers for food and space. Lake chub appear to be the more numerous of the two minnows. Their rarity in Kananaskis and Barrier reservoirs cannot be explained. Time differences in introduction is not likely the answer.

Brook sticklebacks are most successful in beaver ponds. The seasonally changing habitat of Lower Kananaskis Reservoir has evidently not caused their extinction. Their failure to colonize Barrier Reservoir, despite their occurrence in sloughs at the head end, may be due to the relatively rugged and steep shoreline which does not provide them with a suitable environment.

B. General

Elton (1958) has observed that invaders are most likely to become dominant in simplified and unstable environments. The great increase in brown trout, white suckers and lake chub over other species may not have occurred had stable environmental conditions existed. However, all changes of the fishes in the Kananaskis system have also been observed in physically stable environments. The new species to the Kananaskis system have thus successfully established themselves in partly new niches, often to the detriment of previously established species.

H. Kalleberg (per. comm. 1961) states that in Sweden after construction of fluctuating reservoirs there is an increase in plankton-feeding fish and a decrease in bottom-feeding and piscivorous fish. This is a poor generalization for the Kananaskis system, probably because of the great abundance of chironomids.

Larkin (1956) points out that cold-water fishes have generalized feeding habits and have a relatively wide tolerance of habitat type. Although preference is shown when there is a variety of food, they generally eat what is available. It is therefore considered that food changes were relatively

unimportant for each fish species. The importance of certain food items, however, may have been overlooked (see Johannes et al, 1961).

Intraspecific competition for food is likely severe among the brown trout of certain sloughs at the southern end of Barrier Reservoir and among the cutthroat trout of Lower Wasootch Beaver Pond because of the large size range in each age class. Brown(1957) observed a wide variance in size - frequency of sparse and dense brown trout populations and stated that growth was best in medium-sized populations. Larkin et al.(1950) concluded that intensity of competition is shown by the size range at a particular age in rainbow trout. Magnuson(1962) has shown the same phenomenon to occur among medaka sibs grown in isolation under the same environmental conditions. He also notes that when food is limited in a population,growth advantages occur in socially dominant individuals.

Lagler(1956) states that most fish can tolerate both wide ranges and rapid changes of acidity and alkalinity and that trout may live in waters of greater $[O_2]$ than four or five p.p.m. (2.8 - 3.5 c.c.l.). It is therefore unlikely that pH and $[O_2]$ had any selective influence on the fishes. None of the fish approached their high lethal temperatures as given by Black(1953), Brett(1944), and Wiggins (1950).

Dogiel et al.(1958) point out that there is usually a lowering in the abundance of parasites immediately after flooding a reservoir, with a subsequent rise in their numbers. It is unlikely that parasites would cause any of the changes in the fish,

but rather changes in the fish and invertebrate fauna would explain changes in the parasites.

Construction of reservoirs for hydro-electric power has changed the physical environment and contributed to the observed change in the species composition. The decrease in game species was, however, largely due to the introduction of non-game species and failure to manage properly the fisheries. The latter two, by themselves, would probably have created a situation similar to the present and similar to Lower Kananaskis Lake in 1936 when longnose suckers predominated.

XII. FISHERIES MANAGEMENT OF THE KANANASKIS RIVER SYSTEM

The general opinion of the Calgary Fish and Game Association in 1946 was that reservoirs would spell doom to the game fishes of the Kananaskis system. Rawson(1948) concluded that game fish production was still possible in these reservoirs and advised that continuous research and management be carried out. However, Miller et al.(1959) predicted that Salmo spp. would vanish from Lower Kananaskis Reservoir and generally overstated the deterioration in Upper Kananaskis Reservoir. They blamed all changes in fish composition on reservoir construction and did not take into consideration species interaction.

Andriano (per. comm. 1962), Chief of Fisheries for Utah, believes that reservoirs are capable of producing excellent trout populations if competition (mainly for space) from non-game species is removed. Nikolskii (1962) rightly points out that fish populations do have adaptive responses to changes in the environment.

Unfortunately, the limit of these adaptive changes is unknown for most of the economically important species.

Jenkins (1961) expressed the view that reservoirs have brought into existence new areas capable of fish production and has shown the need for more research. The recreational pleasure derived from these bodies of water is still great and increased public use of the Kananaskis area will demand that more attention be paid to the fisheries. It is behooving that continued research be done in the area and the results applied to the management of the fisheries.

The 1961 study has suggested the following recommendations:

1. Remove small falls and beaver dam near the mouth of Boulton Creek. The creek is spread over a wide area where it passes over the falls and confinement to one channel would allow greater numbers of rainbow trout and Dolly Varden to reach suitable spawning area.

2. Construct artificial spawning channels on Kent and Boulton creeks. Cold creek temperatures would force most of the fry into the reservoir, thus prohibiting formation of resident creek populations of any size.

3. Keep Boulton and Smith-Dorrien creeks closed to fishing. This would allow greater numbers of fish to reproduce successfully and increase the reservoir fishery.

4. Plant rainbow trout eggs in Boulton and possibly Kent and Smith-Dorrien creeks. Stock marked yearling rainbow trout in Barrier, and in Lower and Upper Kananaskis reservoirs

as part of an experimental program to note effectiveness of stocking. Smith (1956) has noted good survival of hatchery trout planted with wild trout. In large lakes, predation of rainbow trout on their young is absent or rare (S.B. Smith, per. comm. 1962). The stocking of yearlings in large bodies of water in the presence of wild stocks can contribute to the fishery.

5. Stock beaver ponds biennially with brook and cutthroat trout. This will provide a variety of species to anglers. Cutthroats should preferably be planted in beaver ponds where sticklebacks occur, i.e., Grizzly and Willow. They should not be stocked in Wasootch beaver ponds where the only native Kananaskis cutthroat may exist.

6. Conduct more research, coupled with public education, to determine the advisability of poisoning the Kananaskis system. The latter could be done economically and completely at low water levels using toxaphene in the reservoirs and rotenone in the river. Beaver ponds may be left untouched, except where brown trout occur. Restocking Upper Kananaskis Reservoir with rainbow trout, Lower Kananaskis and Barrier reservoirs with rainbow trout and Dolly Varden (preferably of native stock held in hatchery) could follow. Brown trout should not be introduced. Stream-dwelling brown trout are often regarded as a "trophy" fish by anglers and are preferred by skilled fishermen. Unskilled fishermen seldom catch them. However, brown trout are seldom fished for in the Kananaskis system because adults are rare in the river. Since other fish do not flourish in the presence of brown trout and brown trout are not easily caught, their occurrence will deprive many of fishing pleasure while giving enjoyment only to a few.

XIII. SUMMARY

1. Fishes of the Kananaskis River system were studied during the summer of 1961 to suggest reasons for changes in the species composition.
2. Little change has occurred since 1936 in the distribution of mountain whitefish, longnose dace, and brook sticklebacks.
3. Competition from white suckers and decreased and changed spawning ground areas in Lower Kananaskis Reservoir have caused a reduction in the number of Dolly Varden and rainbow trout.
4. Decreased temperatures and daily fluctuations of the water level have probably caused the reduction of rainbow trout in the Kananaskis River.
5. Brown trout are highly successful in their habitat and have displaced Dolly Varden, brook trout, cutthroat trout, and rainbow trout where their ranges overlapped.
6. Introduced brook trout are successful in beaver ponds.
7. Cutthroat trout have been adversely affected by brown trout and rainbow trout. Native Kananaskis stocks are near extinction.
8. White suckers, lake chub, and longnose dace have greatly increased in numbers since their introduction. The latter two, however, remain scarce in Kananaskis and Barrier reservoirs.

9. The succession of white suckers over longnose suckers in Kananaskis and Lower Kananaskis reservoirs is unexplained.
10. Changes in the invertebrate fauna and chemical characteristics of the reservoirs are considered relatively unimportant.
11. Introductions of new species of fish and changes in the spawning grounds~~, and lack of proper management of the fisheries~~ have caused ~~the greatest~~ a decrease in the game fishes.
12. Power dams, acting as physical barriers, and fluctuations in the water level in the associated reservoirs, probably have had little to do with the change in species of fish.
13. Intensive research on the reservoirs is urged in the hope of improving the fishery.

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APPENDIX A. Gillnetted fish used in calculating the length-weight equations and growth curves.

Species	Total No. Caught	Length-Weight Equations			1961 Growth Curves			
		Length Range (cm)	Wt. (gm) Range	No.	Length Range (cm)	Age (Yr) Range	No.	Fig.
KANANASKIS RESERVOIR								
Mountain whitefish	63	12.5-36.0	26-600	48	12.5-35.0	1^+-6^+	40	27
Brown trout	25	11.9-43.5	25-900	25	12.0-43.5	1^+-4^+	19	31
White sucker	62	11.0-41.0	16-1000	47	-	-	-	-
BARRIER RESERVOIR								
Mountain whitefish	525	11.5-34.5	15-400	53	9.5-34.5	1^+-6^+	38	27
Brown trout	83	11.5-60.0	14.5-1900	34	11.5-60	1^+-8^+	34	31
Longnose sucker	264	11.1-46.0	17-1375	45	-	-	-	-
White sucker	194	11.0-44.0	17-1200	45	-	-	-	-
LOWER KANANASKIS RESERVOIR								
White sucker	133	32.5-43.0	550-1325	60	-	-	-	-
UPPER KANANASKIS RESERVOIR								
Rainbow trout	39	10.0-45.0	13-875	31	-	-	-	-
Longnose sucker	160	11.0-35.5	15-550	55	-	-	-	-

APPENDIX B. Gillnetted fish used in calculating the gonadosomatic index.

Reservoir	Species	Date	GSI range (%)	Weight range(g)	Number
Kananaskis	Mountain Whitefish	Aug. 16	0.5 - 12.5	120 - 600	17
Barrier	Mountain Whitefish	May 13- June 20.	0.2 - 2.5	130 - 425	48
		August	6.6 - 19.0	125 - 450	18
	Brown trout	May 13- June 21.	0.1 - 1.3	210 - 1900	16
	Longnose sucker	May 19- June 13.	0.1 - 15.0	225 - 1375	31
	White sucker	May 13-	0.4 - 15.9	425 - 1125	52
Lower Kananaskis	White sucker	July	1.0 - 16.1	550 - 1325	28
Upper Kananaskis	Lake chub	July	6.0 - 18.0	14.0 - 16.8	17

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